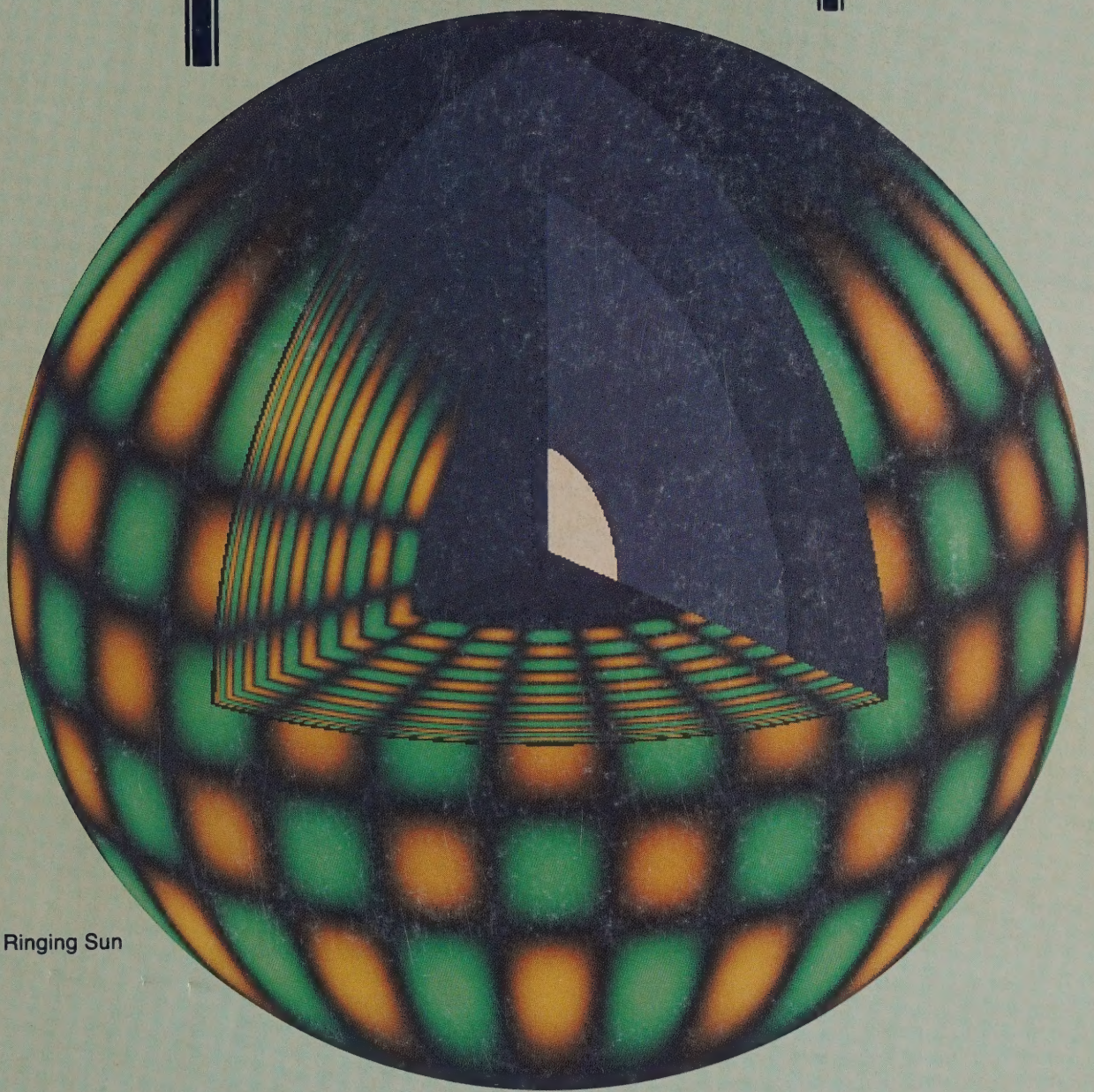
November 1987
$2.50

Sky & Telescope



The Ringing Sun

What's Inside Our Sun? ★ S&T Tests the CAT
Working Together: Amateurs and Professionals
Ultrafast Film ★ 42-inch Amateur Reflector

0 11
73361 64721

© Questar Corporation 1987

Photograph by Hugh Entrop on 35 mm Ektachrome 200. Exposure one hour at f/13.5.

A LETTER TO QUESTAR

Ownership of a Questar® since 1978 has given me ample opportunity to use it in a variety of situations. What it has taught me is that it is capable of bringing me more astronomy than I can absorb. Whatever my interest — deep sky, planetary, double stars, lunar, comets, or eclipses — my Questar has carried me through. And because it is easily portable, has done the job wherever I happened to be.

There are a number of areas on which I would like to comment:

Light Grasp — With the 3.5″ Questar I have easily located such traditionally difficult objects as Barnard's Galaxy in Sagittarius (NGC 6822), NGC 2158 (near M35), Andromeda's NGC 891, the Pleiades nebulosity around Merope, and several faint globular clusters including Coma Berenices' NGC 5053 and Scorpius' NGC 6144. The two arcs of Cygnus' Veil Nebula present no challenge whatsoever, falling prey to the Questar on almost any clear dark night.

Resolution — The Questar consistently elongates Gamma-2 Andromedae (0.55 arc-second) and easily shows the fifth star in Orion's Trapezium. Delta Cygni, widely regarded as a test for a 4″ telescope, yields to Questar. Jupiter and Saturn are beautiful. The Jovian belts and satellite shadows are well defined under almost all conditions. I have identified 5 of Saturn's satellites (said to be a test for a 6″) and can follow Cassini's Division completely around the ring when the planet is properly oriented. While not a student of the Moon, I have found the amount of lunar detail incredible. With the right illumination, seeing half a dozen craterlets on the floor of Plato is not unusual.

Contrast — One underrated characteristic of the Questar is its superb contrast. There is an often-stated assumption that long-focus instruments are not good for deep-sky work. Those who have used refractors or other well-made long-focus instruments know better: the increased contrast of such systems can often make up for the additional light-gathering power of faster telescopes. The Questar's contrast has enabled me to observe the complete Messier catalog from the less than ideal locations of Tacoma, Washington, and Columbus, Ohio, and to locate the H II region in M33 (NGC 604) from Columbus, Indiana.

Portability — Questar's portability has enabled me to observe from such widely spread locations as Seattle and Mt. Rainier, southern Florida, Cape Cod, New Orleans, San Francisco, St. Louis, Colonial Williamsburg, south Texas, and my current home in Columbus, Ohio. Without a telescope that I could carry with me I would never have seen the wonders of Omega Centauri and the Jewel Box in Crux (NGC 4755) nor observed the 1979 and 1984 solar eclipses. In fact, I take it with me when I travel even if I don't expect to use it. It takes up so little room that there is no point in leaving it at home.

Granted, many of the above observations may be routine for some larger telescopes (including my own) but the fact that they can be made with a telescope that fits under an airplane seat demonstrates that you don't have to compromise your interest in serious amateur astronomy when you purchase a small telescope; that is, if it is the *right* small telescope. Because my Questar can do what it does, I use it almost exclusively. With its precise clock drive, setting circles, stable mounting, and exceptional performance, it is simply more fun to use.

Ronald L. Ravneberg

LET US SEND YOU OUR LITERATURE DESCRIBING QUESTAR, THE WORLD'S FINEST, MOST VERSATILE TELESCOPE. PLEASE SEND $2 TO COVER MAILING COSTS ON THE CONTINENT. BY AIR TO SOUTH AMERICA, $3.50; EUROPE AND NORTH AFRICA, $4; ELSEWHERE, $4.50. INQUIRE ABOUT OUR EXTENDED PAYMENT PLAN.

QUESTAR

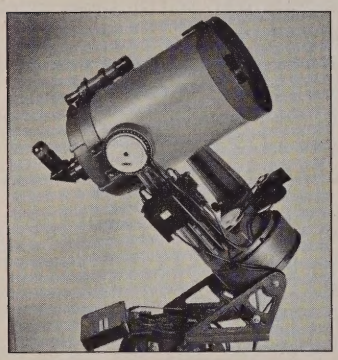
P. O. Box 59, Department 114, New Hope, Pa. 18938
Phone (215) 862-5277

Sky & Telescope®

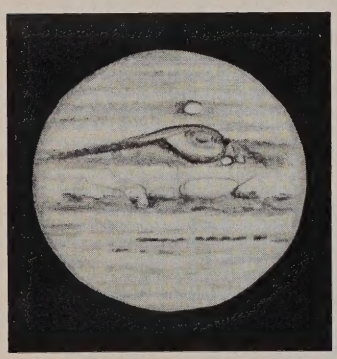
© 1987 Sky Publishing Corp. All rights reserved.

Vol. 74, No. 5 **November 1987**

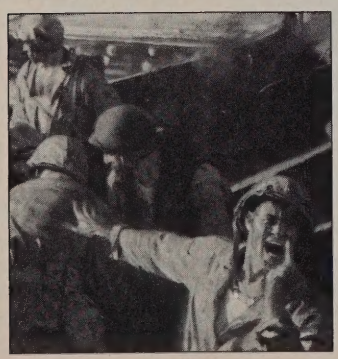
480



484



510



526

464 The Spectacular O Stars *James B. Kaler*
Hottest, bluest, brightest, rarest, and most massive, the *O* stars form the blazing tip of the main sequence.

470 GONG: To See Inside Our Sun
John W. Harvey, James R. Kennedy, and John W. Leibacher
A new telescope network will tell us why the Sun rings like a bell.

477 Supernova 1987A after 200 Days *Ronald A. Schorn*
The supernova continues its slow decline in brightness while the passage of time is gradually revealing the explosion's long-term behavior.

480 Amateurs Triumph in Paris *Stephen J. O'Meara*
Amateur contributions to astronomy are assessed at an IAU colloquium.

484 *S&T* Test Report
Sky & Telescope introduces product reviews with a tryout of the CAT.

535 AMATEUR ASTRONOMERS Amateurs and professionals unite in England

526 ASTRONOMICAL COMPUTING The tide at Tarawa

487 BOOKS AND THE SKY The *Sky & Telescope* guide to astronomy textbooks

510 CELESTIAL CALENDAR Transit times of Jupiter's Great Red Spot

454 50 AND 25 YEARS AGO

452 FOCAL POINT Astronomy and the war for scientific literacy

543 GLEANINGS FOR ATM's World's largest amateur reflector?

453 LETTERS

455 NEWS NOTES

558 OBSERVER'S PAGE Skyshooting with the fastest color film

507 RAMBLING THROUGH THE SKIES The ecliptic slip

506 SOUTHERN STARS FOR DECEMBER-JANUARY

Cover: Our Sun is not static but oscillates in many millions of modes simultaneously. This computer-generated image gives us a snapshot of how different parts of the Sun are moving in response to one particular oscillation. Yellow regions represent areas moving toward us, while green distinguishes those moving away. Places that are always at rest, the so-called nodes, appear as dark lines. Oscillations having different periods penetrate the solar interior by different amounts. In the cutout, the Sun's core, radiative zone, and convective envelope are shown. More details can be found on page 470. Courtesy National Solar Observatory.

Secret Weapon: Astronomy

IN RECENT YEARS the public outcry about the sorry state of precollege science education in the United States has reached a fever pitch. Yet the sobering reality is that the average high school student in this country still takes only one year of science.

The reason is all too obvious. Today's physics, chemistry, and biology courses may be challenging to motivated students, but such offerings can be overwhelming. They attempt to cover everything with a density of concepts that often proves incomprehensible. Students respond by not enrolling, thus prematurely shortening their scientific education.

A stimulating and understandable astronomy course could attract high schoolers back to science. Granted, astronomy is neither more worthy nor more important than other sciences traditionally taught in schools. But it *is* more visual. It is on the frontier of scientific discovery yet not so esoteric that the student cannot grasp the subject matter. Moreover, astronomy — like sports — involves adults long after their school days. This is amply demonstrated by the continued popularity of planetariums, swelling attendance at public observing sessions, and strong sales of small telescopes.

So, we might ask, can astronomy be enlisted to fight in the war for scientific literacy? Absolutely! And at present the National Science Foundation is supporting a program to do just that at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. Project STAR (Science Teaching through its Astronomical Roots) is developing a curriculum that aims to increase the quantity and quality of astronomy taught in high school.

In Project STAR we deal with a limited number of concepts, returning to them in a variety of settings ranging from the classroom to the universe at large. Astronomy provides a diversity of scales of size and distance with which students can work. They can see the same principles at play throughout the universe, and by repeating the same basic concepts, they can master them.

While astronomy is the disciplinary focus of Project STAR, the goal is to help students grasp the essence of science and mathematics in general. Much of the mathematics of astronomy is familiar to the student but has rarely been applied to real situations. Ratios, similar triangles,

estimation, and graphing come alive in astronomy as powerful tools that help students and scientists make sense of the world.

Project STAR directly challenges students' misconceptions. For example, interviews show that most adults think it is hotter in summer than in winter because the Earth is closer to the Sun in summer. The traditional textbook explanation of the real cause of the seasons apparently makes little impression on them. On the other hand, when students determine for themselves that the Earth is farther from the Sun during northern summer, they see that they need a new explanation.

We humans seem to learn best by doing. How would you feel, after all, about being cut open by a surgeon who has never operated on anyone before, but who has read many books on the subject and done very well on many fill-in-the-blanks tests on surgery? Think of something you can do well; how did you learn it? Effective science teaching is based on activities — lots of them.

One does not need powerful, large-aperture telescopes to investigate the sky. Many exciting observations can be made using simple telescopes costing less than 75 cents yet superior to Galileo's. Students can map the Moon's "seas" and highlands, estimate the sizes of its largest craters, and discover the variety of creatures in the astronomical zoo.

Astronomy is a spatial science. However, most students have great difficulty mastering the spatial relationships posed in most textbooks. So STAR has developed a 50-cent celestial sphere that students assemble. With it they determine the changing position of the setting Sun throughout the year, find the constellations overhead at 9:00 p.m. tonight, and plot dim objects to observe with telescopes or binoculars. Later they go on to build three-dimensional models of constellations and groups of galaxies.

How bright is the Sun? How far away are the stars? The distance-brightness relationship is a fundamental tool in astronomical measurement. Students easily find the power output of the Sun using a light bulb and a simple null photometer made from paraffin and aluminum foil costing less than a quarter. Using this as a reference, and assuming the brightest stars in the sky are similar in output to our Sun, students estimate stellar distances with a flashlight and a short length of optical fiber.

Late last year we completed a census of the astronomy offerings in U. S. high schools. We located 408 teachers of semester-length or longer high school astronomy courses and estimate that twice that many remain to be identified.

Many of these teachers belong to astronomical organizations and read *Sky & Telescope* regularly. For them astronomy is not just a course they teach but a lifelong avocation. Most have developed a unique astronomy course or written their own curriculum materials and laboratory activities. What other subject generates that sort of grass-roots interest?

This group may represent the cream of the crop of dedicated science teachers in the United States. Others who are interested in astronomy but do not presently offer a course could be helped by the example of these trailblazers. By sponsoring workshops we expect to encourage the proliferation of astronomy courses. Experienced and enthusiastic astronomy teachers are the natural choice to lead and speak at these events.

We encourage anyone who shares our goals to contact us. Only by mustering all available resources can we strike a blow for scientific literacy. Let's have an astronomy course in *every* high school.

PHILIP M. SADLER

Now the director of Project STAR, Sadler has been a science teacher, curriculum developer, and businessman. In 1976 he invented the Starlab portable planetarium.

Focal Point *invites contributions from readers who wish to comment on contemporary issues in astronomy and space science.*

LETTERS

Fewer Papers

Contrary to your report, there were *not* over 100 papers submitted by late April to *Physical Review Letters* on the subject of the neutrino rest mass as derived from observations of Supernova 1987A (July issue, page 14). This would indeed have been a remarkable number of submissions, but it did not happen. By the end of April we had only received about 10 papers on mass estimates and 26 on all aspects of the supernova (the latter number climbed to 36 by the end of July). Your report has led some readers to believe that we have been too restrictive in our selection of papers to publish, and as editor of *Physical Review Letters* I am glad to set the record straight.

STANLEY G. BROWN
P. O. Box 1000
Ridge, N. Y. 11961

An Hour Makes All the Difference

I found Stephen J. O'Meara's article on the lunar Straight Wall (June issue, page 639) quite interesting, as I had recently sketched this fascinating feature. I noticed the straight, wide shadow of the wall last November, as the Sun rose over Mare Nubium. I made a rough sketch of the scene at the eyepiece and went inside to complete it. After about an hour I returned to the telescope to verify the detail in my drawing. To my astonishment, the wall's shadow had narrowed to a thin line. This, I thought, was worthy of another sketch, since it demonstrated graphically the rapid orbital motion of the Moon. Afterward, I created ink drawings from the charcoal originals (see the illustrations below). They are probably typical of the views seen by other amateurs with moderate-size telescopes.

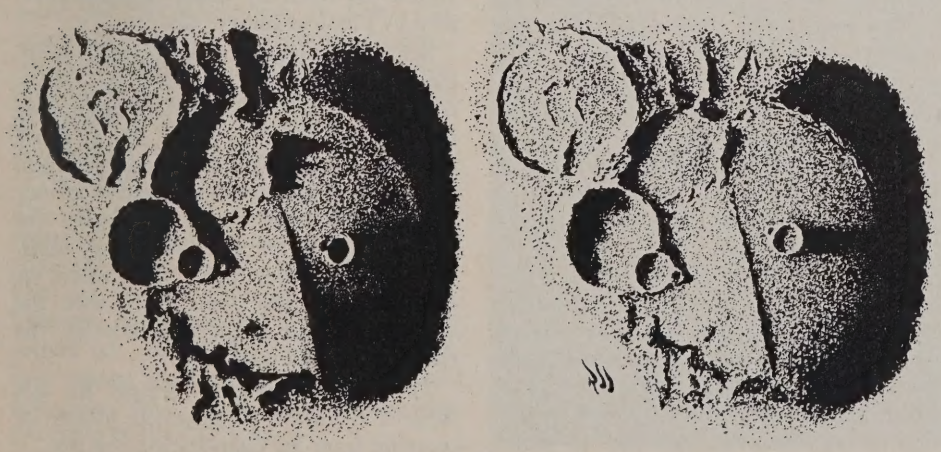
RON DAWES
4438 Bikini Dr.
San Antonio, Tex. 78218

Who Needs the Space Ring?

Chet Raymo's enthusiastic approval of the now defunct French space ring (July issue, page 5) is an affront to the millions of people he claims would enjoy seeing it. Surely the technology responsible for "multichannel television, instant global communications, and satellite astronomy" should carry to the disenfranchised more than a fun show. Already blessed with global sea, land, and air pollution, are the world's billions to be treated to space pollution as well?

If, as I do, Raymo wants people to enjoy celestial splendors on a colossal scale, such splendors already abound. Even before I finished reading his endorsement of the ring idea and "the prospect of five billion people gazing at a wonderful apparition in the night sky," I was telling myself that those same people currently have dozens of celestial apparitions in the sky — visible at no cost and without technical aid.

Surely it is naive to suppose that an artificial glowing ring is going to turn five



These ink drawings show how much shadows near the lunar Straight Wall can change in just over an hour. Ron Dawes made his observations on November 9, 1986, at 3:00 UT (left) and 4:15 UT (right). The Moon was roughly 30 hours past first quarter. Dawes used a 10-inch Dobsonian at 190x. These illustrations originally appeared in the Randolph AFB Astronomy Club's *Amateur Astronomer*.

SKY & TELESCOPE

Editor: Leif J. Robinson
Managing Editor: William E. Shawcross
Senior Editor: J. Kelly Beatty
Technical Editor: Ronald A. Schorn, Ph.D.
Associate Editors: Dennis di Cicco, Roger W. Sinnott, David H. Smith, D.Phil.
Assistant Editors: Mollie D. Boring, Richard Tresch Fienberg, Ph.D., Stuart J. Goldman, Stephen James O'Meara
Advertising: Lester J. Stockman
Marketing: William R. Lawrence
Sky Books: Alan M. MacRobert, *director*, Alan Hirshfeld, Ph.D.
Production: William H. Bonney, *manager*
Design: Martha Myers
Design coordination: Susan W. Gilday
Graphic arts: Ron Arruda, Charles T. Baker
Illustration: Steven Simpson
Photography: Dennis Milon
Proofreading: Carla M. Thompson
Typesetting: Margy MacRobert
Fulfillment: Virginia K. Brewer, *director*
Subscriptions: Sarah E. Bulger, *manager*, Theresa Downing, Anna Vergona
Other Sky Publications: Ellen M. Betz, Cheryl Simmons
Accountant: Julius A. Visconti
Business Manager: John J. Simmons, Jr.
Shipping: Lawrence Babin

SKY & TELESCOPE (ISSN 0037-6604) is published monthly by Sky Publishing Corporation, 49 Bay State Rd., Cambridge, Mass. 02238-1290. Telephone: 617-864-7360.

All rights reserved.

Second-class postage paid at Boston, Mass., and at additional mailing offices. POSTMASTER: Send address changes to **Sky & Telescope, P. O. Box 9102, Cambridge, Mass. 02238-9102.**

SUBSCRIPTION: $20.00 per year in the United States and possessions; $37.00 for two years; $54.00 for three years. See the coupon facing the inside back cover for more information and foreign rates. Single copy of current volume, $2.50; foreign, $3.00. Back issues available from 1980, $3.00; foreign, $4.00. Order from address above. *Microform editions* from 1941 and xerographic copies: University Microfilms, 300 N. Zeeb Rd., Ann Arbor, Mich. 48106. Microform editions are also available from Information Access Co., 404 Sixth Ave., Menlo Park, Calif. 94025.

ADVERTISING: Rates are sent on request and are listed in *Standard Rate and Data Service.*

EDITORIAL: Send all correspondence and manuscripts to our Cambridge offices. Reader contributions welcome — write for author's guide.

COPYING: Authorization to photocopy items from *Sky & Telescope* for internal or personal use, or the internal or personal use of specific clients, is granted for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that a fee of 25 cents per page per copy is paid to CCC, 27 Congress St., Salem, MA 01970. Specify 0037-6604/87 $0.00 + .25.

CITATIONS: Articles are indexed in *Astronomy and Astrophysics Abstracts, Astronomy and Astrophysics Monthly Index, Book Review Index, IBR, IBZ, The Magazine Index, Monthly Periodical Index, Physics Abstracts, The Readers' Guide to Periodical Literature.*

TRADEMARKS: *Sky & Telescope* and design, *Sky and Telescope,* Sky Publications, Scanning the Skies, Book Faire, and ESSCO are registered trademarks of Sky Publishing Corporation.

SKYLINE (astronomy news): 617-497-4168.

50 and 25 Years Ago

The Telescope
November-December, 1937

For these are not ordinary stars; they are not even ordinary novae, which are themselves most extraordinary stars. They are so much brighter than the more usual novae, so much more extreme in all their doings, that they have earned the name SUPERNOVAE, now applied to them by almost all astronomers.

. . . Even today, when the spectra of five supernovae have been photographed, there are wide differences of opinion; differences concerning not only the interpretation of the observed facts, but the facts themselves. The spectra are not the clean-cut, complex groupings of bright and dark bands that the novae display. They show what was first taken to be a series of broad dark bands, but is now almost universally considered to be a few very wide *bright* lines.

When Cecilia Payne Gaposchkin wrote her review article 50 years ago, the stupendous difference between supernovae and novae had just become clear. On the other hand, astronomers had not yet distinguished between the different types of supernovae, and the identities of the host stars for these tremendous explosions were a complete mystery. Of course the energy sources for these cataclysmic events were still unknown, for the science of nuclear physics was very much in its infancy. Finally, there was no inkling of the pivotal role that supernovae play in enriching the interstellar medium with heavy elements and in triggering star formation. The confusion about the nature of supernova spectra was finally sorted out when it was realized that they consist basically of strong continuous emission, upon which are superimposed both absorption and emission lines.

Sky & Telescope
November, 1962

Is the mass of the universe all in the form of galaxies, or is there a significant amount of material spread out in intergalactic space? The most direct test is a search with radio telescopes for neutral hydrogen gas.

The latest attempt has been reported by S. J. Goldstein, Jr., Harvard Observatory. . . . He concluded that . . . there are less than 70 hydrogen atoms per cubic meter in intergalactic space.

In general, the space between galaxies seems to be remarkably empty. No all-pervading medium has been detected, while the first isolated, galaxy-sized cloud of neutral hydrogen was not discovered until early in this decade — by radio observations.

LETTERS

billion people into avid sky watchers. The Sun, Moon, and planets; auroras and zodiacal light; meteors and Halley's comet; and, yes, even bright satellites by the dozen have failed to do that.

The utter insanity of space rings and all similar clutter should be greeted with a resounding "No!" — if not from five billion people deprived of a little show, then at least from those in power who have the guts and determination to enforce international restraint before it is too late. By the way, the same goes for "Star Wars," another big space polluter.

FR. LUCIAN J. KEMBLE, OFM
P. O. Box 430
Cochrane, Alta. T0L 0W0
Canada

Martian Canals — No Mystery after All

Ivan Dryer's photograph of Mars in the June issue, page 605, is remarkable. I only glanced at it and saw the "canals" exactly where Percival Lowell drew them. These features must really exist, but they don't have to be thin, straight, uninterrupted and sharply defined lines.

The resolution of Earth-based photographs is rather low because our atmosphere blurs fine detail. Therefore several small objects on Mars can fuse into a line. A good example is the canal emanating from Margaritifer Sinus, which is easily visible on Dryer's photograph. A good albedo map of Mars shows that this feature consists of two elongated, dark markings — Oxia Palus and Deuteronilus.

Basically we can say that the better the seeing, the fewer the canals. Under optimum circumstances an observer won't see long, straight lines, save for, say, Valles Marineris. The dark markings we see in a telescope have almost nothing in common with topographic features. They are simply surface regions where the soil is darker than its surroundings.

Some astronomers say that it is pointless for amateurs to chart the Martian surface because spacecraft have already done that more precisely. Such a statement is fundamentally wrong. Through telescopes we can observe albedo markings in continual change due to windborne transport.

MARTIN STANGL
Liebiggasse 26
A-8010 Graz
Austria

Quantized Redshifts Are Real

I was interested to read the letter from Stephen Schneider (May issue, page 469) responding to the article I coauthored with John Cocke on quantized galaxy redshifts (January issue, page 19). I thought we had made it clear that even if galaxy redshifts can have only certain "preferred" values, it may still be possible to explain the redshift as a velocity effect — albeit one subject to an unexpected set of quantum rules. Schneider's implication that our hypothesis rules out a velocity interpretation for part or all of the redshift is not correct.

Several recent developments are worth noting. Cocke and I have completed new studies of galaxy pairs. Among isolated pairs, which provide a more critical test of quantization than the groups Schneider considered, scatter in the data is reduced and the tendency of redshift differences to fall near zero or multiples of 72 kilometers per second is distinct.

We also find that when the number of galaxy pairs is plotted against the redshift difference between members, the "zero" peak is actually displaced from zero. The same quantization and zero avoidance are seen in new data from Linda Schweizer (Carnegie Institution of Washington), who studied a sample of Southern Hemisphere galaxy pairs. The latter effect poses a new problem for dynamicists but is a logical consequence of a quantum picture. By analogy with atomic physics, it appears that an exclusion principle is at work and that identical redshifts are forbidden within the relatively small volumes occupied by physical galaxy pairs.

Schneider suggests that statistical problems or observational selection effects could cause the redshift differences among galaxies in pairs to peak at a single nonzero value. We have used stringent criteria to minimize contamination of our samples and have tested specifically for the most important selection effect: omission of very wide pairs. But when we deliberately choose wide pairs with the smallest possible redshift differences, the redshifts are still quantized.

The best observations simply do not support Schneider's suggested means of escaping from the quantization concept.

WILLIAM G. TIFFT
Max Planck Institute
for Radio Astronomy
D-5300 Bonn 1, West Germany

NEWS NOTES

Lambda Orionis' Molecular Ring

Most *O* and *B* stars in our galaxy are found in groups near the edges of cool molecular gas clouds, with the youngest stars closest in and progressively older ones farther and farther away. Bubbles of ionized hydrogen (H II) around the hot young luminaries appear like blisters on the cloud's surface, but the structure and integrity of the molecular region is otherwise unaffected.

What would happen if a massive star formed deep within a molecular cloud? New evidence suggests the star's expanding H II region might completely disrupt the surrounding gas, breaking the parent cloud into several smaller cloudlets.

Ronald J. Maddalena (NRAO) and Mark Morris (UCLA) arrived at this conclusion after taking a detailed look at the molecular gas around Lambda Orionis, the *O*8 star that marks the Hunter's head. Data from the Columbia University radio survey of carbon monoxide (CO) emission from Orion indicate that Lambda is encircled by a patchy, elliptical ring of molecules situated just beyond the zone of ionized hydrogen. These clumps of molecular material coincide with dust seen at infrared wavelengths (see the May issue, page 482) and with several dark clouds and reflection nebulae.

Because the line-of-sight velocity measured from the 2.6-millimeter CO emission line varies smoothly from negative to positive values around the loop, some of the matter is moving toward us and some away (see the photograph at right). The ring must be either expanding, contracting, or rotating. Citing the close association of the molecular clouds with the growing H II region, Maddalena and Morris favor the first explanation.

They find that the positions and velocities of the individual clumps are fit remarkably well by a thin ring some 10° (220 light-years) across, tilted 36° to our line of sight, centered roughly on Lambda, and expanding at about 14 kilometers per second. The size and growth rate suggest the expansion began 2.4 million years ago, which is consistent with estimates of the star's age.

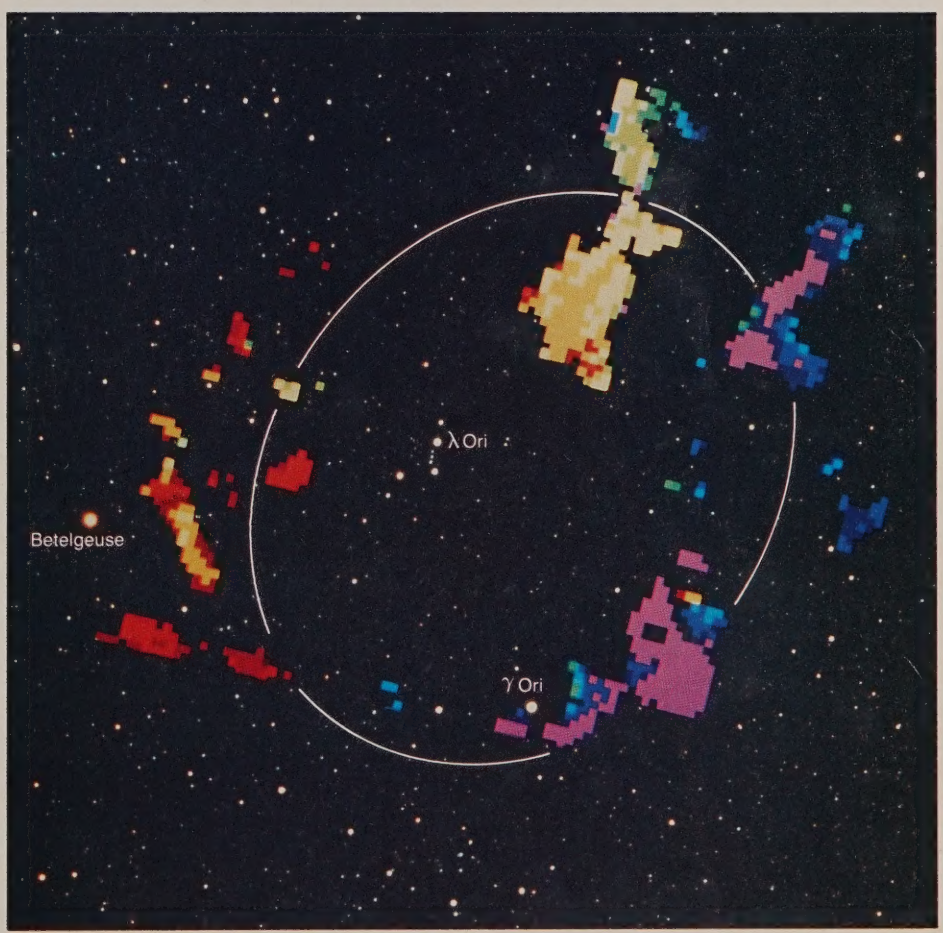
Noting that the CO is confined to a plane, Maddalena and Morris propose that Lambda Orionis was born at the heart of a flattened molecular cloud that no longer exists as a distinct entity. According to their scenario the star's H II region initially grew symmetrically, compressing molecular material into a spherical shell as it went, but once it reached the cloud's nearest surface it broke through and tore the cloud into the fragments we now observe. As stellar ultraviolet radiation streamed outward into the less dense surroundings, the remnant cloudlets rocketed away from the rupture site, their constituent molecules recoiling from dissociations or ionizations.

Unfortunately, this model has one catch: Lambda's presently observed motions along and perpendicular to our line of sight imply that it was nowhere near the center of the molecular ring 2.4 million years ago! Maddalena and Morris suggest several ways out of this dilemma. For example, the star may have recently acquired its anomalous velocities via a close encounter with another object, or perhaps by the expulsion of a stellar companion. Alternatively, the ring may have formed from the action of a supernova that occurred long ago. If Lambda and the progenitor were once members of a multiple star system, the former might now be a "runaway" star.

Further details concerning this unusual system will appear in the December 1st *Astrophysical Journal.*

Still No Asteroid Satellites

For decades astronomers have wondered whether some asteroids have satellites. Such objects may be possible, but observations have been unable to confirm or deny their existence. In an attempt to find such a "moonlet," three scientists at the University of Arizona surveyed 10 of



Clumps of carbon monoxide (CO) trace a ring of cool molecular gas expanding around Lambda Orionis, the Hunter's head. Here the clumps have been color coded to indicate their line-of-sight velocities. Features moving toward the Sun are blue or violet, while those moving away are yellow or red. North is up and east to the left in the 12° field. Dennis di Cicco photograph; CO data courtesy Ronald J. Maddalena.

the largest asteroids — those capable of holding onto a satellite big enough to be seen from Earth. They found nothing.

Tom Gehrels and colleagues began their search in 1984 using university telescopes atop Kitt Peak and in the Santa Catalina Mountains in southern Arizona. Taking charge-coupled-device images of fields of view both near and far from the primaries over several days, they should have detected any secondary objects larger than 2 kilometers in diameter.

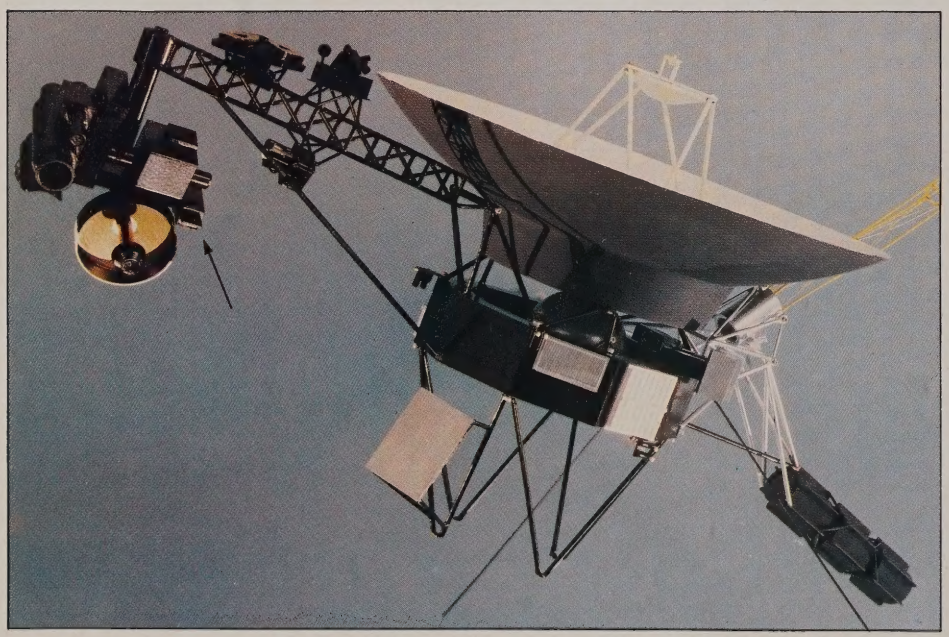
In the May issue of *Icarus,* the team reports that their empty hands are consistent with the low likelihood that an asteroid could hold onto a companion for very long. Previous calculations have shown that during the lifetime of the solar system, collisions in the asteroid belt would have dislodged bodies smaller than 30 km across from orbits around their primaries.

Furthermore, in the aftermath of a possible more recent collision, the velocities of fragments shattered off larger bodies would have to fall into a very narrow range to allow the debris to enter into orbit around the primary. Such a fluke asteroid satellite is possible, but it would be rather short-lived. A more probable pairing of asteroids is a very close or contact binary; two candidates are 624 Hektor and 216 Kleopatra.

Planetary Probes Double as Space Telescopes

Most people would probably characterize the Voyager missions to the outer planets as long periods of boredom punctuated by brief but dramatic encounters with other worlds. But for some astronomers the twin probes' years-long interplanetary cruises are anything but dull. They've been using Voyager 1 and 2's ultraviolet spectrometers — originally built to examine the atmospheres of Jupiter, Saturn, and Titan — to study sources of ultraviolet radiation ranging from mysterious hydrogen emission possibly related to the breakup of comets near Earth to quasars millions of light-years away.

The Voyager instruments currently provide the only ongoing access to ultraviolet wavelengths shorter than about 1200 angstroms, where the Earth-orbiting International Ultraviolet Explorer becomes insensitive. The spectral region from 500 to 1200 angstroms is one of the last to be explored by astronomers. It was to have been the domain of such instruments as the Extreme Ultraviolet Explorer (*S&T:* March, 1985, page 212) and a suite of telescopes carried aboard the Space Shuttle, but until the shuttle flies again, the Voyagers have it to themselves.



The ultraviolet spectrometers (arrowed) aboard the twin Voyager spacecraft are mounted on steerable scan platforms which enable them to point anywhere in the sky. Therefore, even though they were designed to measure the composition and structure of atmospheres, they are well suited to making diverse astronomical observations during the long cruises between planetary encounters. Courtesy Jet Propulsion Laboratory.

University of Arizona astronomer Jay Holberg reports that Voyager observations have played a key role in a surprisingly wide variety of recent studies. In October, 1984, for instance, Voyager 2 recorded a "superoutburst" from the dwarf nova VW Hydri, presumably caused by a sudden change in the rate at which a cool, bloated star rains gas onto an accretion disk around a white dwarf. In the March 1st *Monthly Notices* of the Royal Astronomical Society, Ronald Polidan and Holberg write that the Voyager data provides clear evidence of a delay between the rise in brightness at visible and ultraviolet wavelengths, reveals in the spectrum a break not explained by current models of accretion disks, and offers convincing evidence that "superoutbursts" are preceded by less intense, "normal" ones.

Thanks also to Voyager 2, quasar 3C 273 has become the first extragalactic object detected at ultraviolet wavelengths shorter than 1200 angstroms. The resultant spectrum, which will be published by Gail Reichert (Computer Sciences Corp.) and colleagues in the *Astrophysical Journal,* "has prompted considerable excitement," says Holberg. That's because it hints at the presence of a broad hydrogen absorption feature that, if real, will provide information theorists desperately need to understand the nature of the material shrouding the quasar.

Sailing through space far from the Sun, both Voyagers are able to make extraordinarily long observations. Analyzing a spectrum exposed for 1.5 *million* seconds (17 days), Holberg found that virtually all the sky background radiation between 500 and 1200 angstroms is accounted for by sunlight scattered by interplanetary gas and starlight scattered off interstellar dust. This suggests that astronomers searching for additional, fainter sources of ultraviolet background emission at these wavelengths will have to improve the sensitivities of their detectors.

What will the future bring? For one thing, Voyager measurements of hot stars such as bright *O* and *B* examples and faint white dwarfs will help calibrate the Hubble Space Telescope's ultraviolet instruments (*S&T:* December, 1986, page 562). And astronomical observations made with the ultraviolet spectrometers are slated to become a major part of the scientific investigations conducted during the Voyager interstellar mission following the Neptune encounter in August, 1989.

Quasars: The Movie

Stuart Shapiro and Saul Teukolsky at Cornell University have made a new movie showing how a supermassive black hole might form. Such black holes, containing masses equivalent to 100 million Suns, are thought by many theorists to be the power sources of quasars.

They started with a model composed of a multitude of neutron stars, whose motions were tracked by a supercomputer at Cornell. Some 100 billion calculations were needed, requiring about 10 hours of computer time. The data were then taken to Digital Productions in Los Angeles, where another supercomputer produced the motion picture.

Here's what the movie shows. As the neutron stars swirl around, the inner ones attain nearly the speed of light, and the cluster becomes unstable due to relativistic effects. The cluster collapses, and inward-spiraling stars form the black hole. Then more stars are drawn into the abyss until the cluster's center is swept clean.

When the same modeling technique is applied to a galaxy with a dense core, up to 5 percent of the core stars fall inward to form the black hole — a process that takes only minutes! The remaining stars orbit the black hole and are gradually consumed by it as their orbits decay, thereby providing the enormous, sustained power needed by the quasar.

Shapiro comments, "Our calculations offer a glimpse into one of the most fascinating processes in the cosmos. This is a typical case of a problem in astrophysics that couldn't be solved without a supercomputer. There are literally hundreds of such problems involving nonlinear, multidimensional equations. I think astronomers will be among the prime beneficiaries of supercomputer applications."

The collapse of a multitude of neutron stars to form a black hole. *Frame 1:* A snapshot of the initial distribution of neutron stars, the dominant constituent of the dense cores of galaxies. *Frame 2:* Enough stars have gathered together so that a black hole is created. The blue (outer) ring is the so-called Schwarzschild radius from which spherical light flashes (simulated by the green outward-moving shells) cannot escape. *Frame 3:* Almost all the stars have been consumed by the black hole, whose Schwarzschild radius continues to grow as a consequence of the black hole's increasing mass. *Frame 4:* All the stars have been sucked into the black hole. Note that the "outermost" light pulse in Frame 2 has moved outward only slightly relative to the Schwarzschild radius, showing that it cannot escape. Courtesy Stuart Shapiro and Saul Teukolsky, Cornell University.

Bloated Stars in Quasars?

Closely surrounding the mysterious "central engine" that powers a quasar is a region containing numerous clouds of glowing gas. This material betrays its presence by its characteristic broad emission lines. These objects have puzzling properties. Why doesn't the gas spread out and form one large diffuse cloud, and why do the clumps have only a narrow range of sizes, masses, and densities?

These so-called broad-line clouds actually may be the atmospheres of *bloated stars,* according to Richard C. Puetter (University of California, San Diego). His suggestion is plausible if for no other reason than that quasars are thought to inhabit the centers of galaxies and so should be surrounded by large numbers of stars like our Sun.

Whatever the nature of the "beast" producing the energy, a quasar bathes an object in its vicinity in intense radiation. Puetter's calculations show that as a result, a nearby star's outer atmosphere, comprising only some one-billionth of a solar mass, expands to about 40 times the Sun's size and takes on the properties of a broad-line cloud. The stellar core, on the other hand, is oblivious to the quasar; it does little more than provide the stabilizing gravitational field. Because the quasar ultimately pays the bill, a star's expanded outer envelope can radiate far more energy in emission lines than its underlying core produces by nuclear reactions.

Even in their puffed-up state, bloated stars are reasonably stable for a few million years or so. Over longer time spans stellar collisions are likely and probably supply the fuel on which the quasar's central engine runs.

In an article submitted to *Astrophysical Journal Letters,* Puetter notes that the

bloated-star model has two consequences, both related to its reliance on ordinary stars rather than exotic processes. First, most of a quasar's observed redshift must be due to the overall expansion of the universe. Second, the broad-line "clouds" must be in orbits around the central source, rather than raining inward from some mysterious source or being ejected outward in some unknown manner.

Goodbye Olbers' Paradox!

Why is it dark at night? This question seems silly at first glance, but it has been worrying astronomers at least as far back as Johannes Kepler in 1610. If stars are uniformly distributed in a flat (Euclidean) universe without end, then one of them blocks our view no matter where we look. As a result the entire sky is covered with overlapping star disks (see illustration at right), and every part of the heavens shines with the brightness of an average stellar surface — there is no night. This ridiculous conclusion is obviously wrong, but why?

Astronomers found a temporary way out of Olbers' paradox (as the dilemma has been called since Heinrich Olbers popularized it in 1826) when they realized that the star system surrounding us has a limited size; there will be dark spaces on the sky because in many directions we eventually run out of stars before one of them blocks our view. However, the problem reappeared when it became clear that our Milky Way is just another galaxy in a vast universe filled with such systems. Olbers' paradox was back, this time on a larger scale, for now all of our lines of sight should be blocked by *some* star in *some* galaxy.

A new resolution of the dilemma came in this century with the discovery of two reasons for the dark night sky. The more important cause is the finite age of the universe. Galaxies simply have not been shining long enough for light from the really distant ones to have reached us yet, so in many directions we run out of stars before one blocks our line of sight. The other, relatively minor, factor is the redshift produced by the expansion of the universe. This reduces the number and energy of photons we receive from distant sources (see the February issue, page 140).

For some reason, however, there remains widespread confusion about this subject, confusion that affects numerous elementary textbooks and general references. In an attempt to set the record straight, Paul S. Wesson (University of Waterloo, Ontario) and Kippenhahn Valle and Rolf Stabell (University of Oslo) have presented what they call the definitive resolution of Olbers' paradox.

They calculated the expected intensity of the faint background light produced by distant galaxies in a variety of expanding and static universes. In doing so, they confirmed that the limited age of galaxies and stars is the dominant cause for the dark night sky, while the expansion of the universe is a less important factor. Books that provide a clear and correct explanation of the paradox, as well as some that do not, are listed in the June 15th *Astrophysical Journal.*

Olbers' paradox. In an infinite, flat (Euclidean) universe with stars scattered uniformly through it, our line of sight in every direction is eventually blocked by the surface of a star. As a result, the entire sky is filled with sections of stellar disks, and every part of the heavens blazes with the surface brightness of an average star. If this is so, why is the sky dark at night? See adjacent text.

LA PALMA'S GIANT TELESCOPE

The Spanish observatory at Roque de los Muchachos on the island of La Palma is dominated by this large onion dome for the recently completed 4.2-meter William Herschel Telescope (WHT). The project, conceived and executed by British astronomers, is jointly funded by Great Britain and the Netherlands (*S&T:* March, 1984, page 214). First light was on June 1st and scheduled observing began six weeks later. During the telescope's year-long "running in" period, observing time will be allocated in three-week blocks interspersed by engineering tests, according to project scientist Jasper Wall (Royal Greenwich Observatory). The first observers, Ed Valentijn (University of Groningen), Keith Taylor (Anglo-Australian Observatory), and colleagues, used their three weeks to study internal motions in galaxies and quasars with the new Taurus II scanning Fabry-Perot interferometer. "I am busting to get my project on distant active galaxies going," Wall admitted in an interview with *Sky & Telescope.* "The telescope and site have enormous capabilities. All our expectations are being met as we bring the telescope into full operation." Photograph courtesy Royal Greenwich Observatory.

Oort Cloud Comets: Blasted, Bumped, and Baked?

Astronomers believe that a few trillion comet nuclei exist as a vast spherical halo some 20,000 to 100,000 astronomical units from the Sun. These comets, collectively called the Oort cloud, are so distant that their average temperature is only about 10° Kelvin. Therefore, it is commonly believed that their highly volatile ice surfaces have remained solid and essentially unchanged since the solar system's formation (see the March issue, page 238).

But according to Alan Stern of the University of Colorado, the Oort cloud's comets aren't nearly as pristine as is commonly thought. For example, they routinely encounter high-velocity gas and dust as the Sun courses around the galaxy. Some interstellar gas will tend to stick to the frigid nuclei, but dust will more likely chip away flecks of their surfaces. On balance, Stern calculates, interstellar material has eroded away as much as 8 centimeters (3 inches) of the comets' outer layers since the solar system formed. Smaller bodies have been obliterated altogether.

The newly liberated material then escapes from the solar system to join the interstellar medium. But for a time the comets' outer layers serve as a temporary "sink" for the migrating material. That is, gas and dust once in star-forming clouds are briefly trapped in comet nuclei, then gradually returned to interstellar space. "Dust to dust," Stern says.

Meanwhile, the Oort cloud objects have not been floating idly. They also collide with each other, typically at up to 400 meters per second (900 miles per hour). This action alone may have eliminated any original cloud member less than 10 meters across, while churning and shattering the surfaces of larger ones.

Finally, Stern's work with colleague Michael Shull shows that the comets' ices are so volatile that they evaporate if warmed even slightly — that is, whenever stars pass near the Sun and particularly when they penetrate the cloud itself. The most significant heating would come from stars thousands of times more luminous than the Sun. If one of these chanced to pass through the Oort cloud, its gravity would be strong enough to cast billions of comets deep into interstellar space.

But all those that remained would also be seriously affected. Stern calculates that over the age of the solar system, all of the Oort cloud's comets have been heated to 27° K several times, and roughly half of them have hit 40° K or more. "This region may be the refrigerator of the solar system," he muses, "but the door's left open every now and then by a passing star."

New Evidence Unearthed at Tunguska Site

On June 30, 1908, a cosmic object collided with Earth and devastated part of the Siberian wilderness near the Podkamennaya Tunguska River. Mysteriously, the visitor left no crater, and for decades Soviet researchers have probed the site in vain for its fragments. In all likelihood, no impact actually occurred. Instead, a body perhaps 300 feet across disintegrated explosively several miles above the Siberian taiga. But those who have studied the event cannot agree whether the object was a comet or an asteroid (*S&T:* January, 1984, page 18; December, 1986, page 577).

Now M. I. Korina and five colleagues have identified an excess of the metallic element iridium in core samples obtained at Tunguska. Their finding appears in the abstracts of the 18th Lunar and Planetary Science Conference, held during March.

Iridium is rare in Earth's crust, so any spike in its abundance usually implies an extraterrestrial source. The Moscow group made the discovery in a peat layer 17 to 18 inches below ground level, which they say formed about the time of the cataclysm. A similar concentration of iridium has been found in samples of antarctic ice dating from the same period.

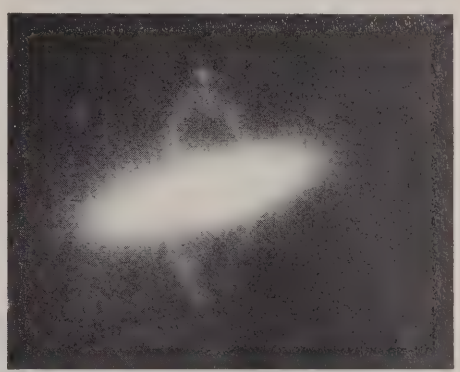
Korina's group estimates that to create the observed iridium enrichment over the entire Earth, several million tons of cosmic dust would be needed. Coincidentally, theorists calculate that the Tunguska object must have been comparably massive, based on the kinetic energy it delivered. Since comets are mostly ice and should contain little iridium, a stony object might seem the more likely source.

However, the researchers suggest that an incoming comet could have been accompanied by a swarm of dusty material. To support this conclusion they cite reports of bright skyglows observed at night over Europe within a few days of the event. Moreover, they say, it seems unlikely that the explosion of a single object over Siberia could distribute a global veneer of debris so evenly.

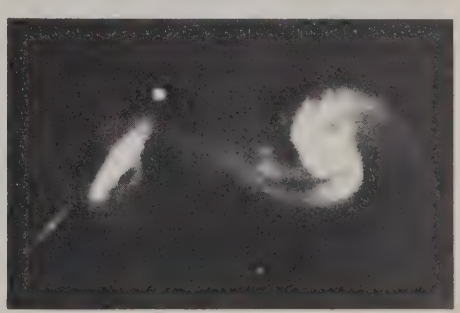
Polar-Ring Galaxies

Polar-ring galaxies are among the most unusual-looking objects in the universe (*S&T:* June, 1984, page 514). They consist of an otherwise normal S0 disk galaxy (an armless spiral) seen edge on and an encircling ring of stars and gas that orbits over the disk's poles, as seen in the illustration below. The cause of this unlikely arrangement may be the merger of a gas-poor S0 with a gas-rich system, or the transfer of material from one galaxy to another (see bottom of page).

The results of two recent investigations of these fascinating composite structures appeared in the March 15th *Astrophysical Journal.* In one study, Jacqueline H. van Gorkom (National Radio Astronomy Ob-



IC 1619 is a polar-ring galaxy comprising an S0 system (armless spiral) seen edge on (a cigar shape is ruled out by velocity measurements derived from spectra), circled by a ring of stars and gas orbiting at right angles to the disk of the main system. This image is a 2-hour exposure in blue light taken by Karen M. Strom and Stephen E. Strom with the 4-meter reflector at Kitt Peak National Observatory. Courtesy Paul L. Schechter.



NGC 3808 seems to be transferring mass to its companion, which may become a polar-ring galaxy. Photograph from Halton C. Arp's *Atlas of Peculiar Galaxies*, courtesy Francois Schweizer.

servatory), along with Paul L. Schechter and Jerome Kristian (Mount Wilson and Las Campanas Observatories) used the Very Large Array radio telescope to map the neutral hydrogen in three S0 galaxies with polar rings. They also obtained new images and spectra in visible light and remeasured old ones.

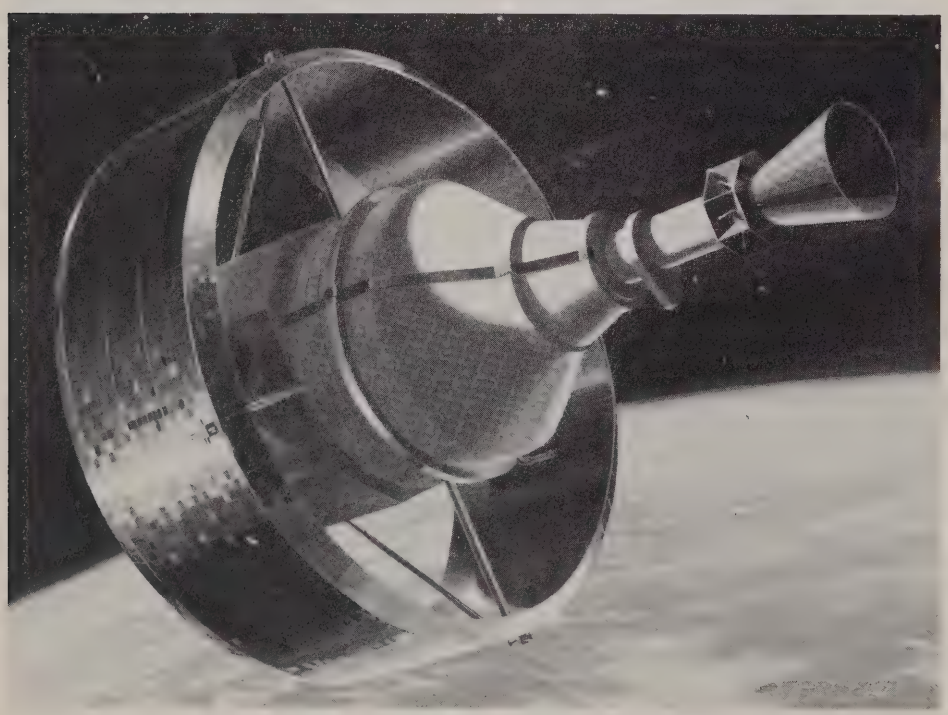
The new data, combined with previous work, shows that the rings vary widely in appearance. The material can be in a relatively stable configuration, producing stars throughout its extent, or it can be distributed unevenly, with stars forming only at the inner edge of a hydrogen disk. Differences in appearance may be due to differences in age, as the initially clumpy rings produced by mergers smooth out with time. This explanation is supported by evidence of stellar debris found near the more irregular rings in visible-light images; presumably this is material left over from the interaction and not yet dispersed.

In related work, Bradley C. Whitmore and Douglas B. McElroy (Space Telescope Science Institute), along with Francois Schweizer (Carnegie Institution of Washington), have taken new visible-light images and spectra of two polar-ring systems in order to study the mysterious dark matter that apparently dominates the halos of many galaxies. Their spectroscopic data can be used to assess the gravitational field in which the rings move. It seems the halos around the S0 galaxies are almost spherical, at least out to the distance of the rings.

Unlikely as it might seem at first glance, the odd-looking rings can last a relatively long time. Those in the two systems studied by Whitmore and colleagues are estimated to have an age of some 1 to 3 billion years, while other examples may be even older.

Satellite To Search for Relativity Proof

Ever since Einstein published his general theory of relativity in 1916, theorists have subjected it to tests of every sort to see whether he was right. So far, with observations of the bending of starlight during solar eclipses and the precession of Mercury's orbit, to name only two, Einstein has passed with flying colors. Now scientists have devised yet another test, which will use space itself as the laboratory.



The Gravity Probe-B satellite, to be launched in the early 1990's, may provide further evidence for Einstein's general theory of relativity. Gyroscopes will measure how space-time is distorted by the Earth's mass and rotation. The nozzle houses the guidance telescope. Courtesy Lockheed Missiles and Space Co.

The experiment will primarily consist of a set of supercooled gyroscopes in a 650-kilometer (400-mile) polar orbit. Launched from the Space Shuttle in the early 1990's, Gravity Probe-B (GP-B) will measure two predicted effects of Earth's bending and pulling of the fabric of the universe, often called space-time.

The first is the result of the satellite moving through the curved space-time surrounding the planet. According to Einstein's theory, the gyroscopes should precess 6.6 arc seconds per year. A much smaller effect, only 0.042 arc second per year, should be detected as the Earth drags space-time along as it rotates. Scientists hope to measure both to a precision of 0.001 arc second per year or better.

Researchers at Stanford University and Lockheed Missiles and Space Co. are busy developing a shuttle-based gravity experiment that will test the components for the later GP-B satellite. The entire $170 million project is under the direction of NASA's Marshall Space Flight Center.

At the heart of the experiment are the four ultraprecise gyroscopes built at Stanford. Within each is a spinning sphere of pure quartz with a thin layer of superconducting niobium. Engineers at Lockheed are designing the surrounding liquid-helium cooling tank and a guidance telescope that will keep the satellite's orientation fixed with respect to the stars.

Supernovae: How Often?

A recent study suggests that supernovae in external galaxies may occur only one-third as often as previously thought. Since November, 1980, Robert O. Evans, a pastor of Australia's Uniting Church, has conducted an intensive and highly successful visual search for supernovae (*S&T:* January, 1984, page 94). During the first five years he accumulated 50,403 observations of 1,017 galaxies and discovered 11 supernovae. He would almost certainly have seen four more if others had not discovered them first.

Sidney van den Bergh and Robert McClure at Canada's Dominion Astrophysical Observatory used these data for a statistical study of the rates at which Type I and II supernovae occur. They found that during any 100-year period, a typical galaxy with a luminosity equal to 10 billion Suns would have 0.7 and 1.1 supernovae of Type I and II, respectively. For the Milky Way, which has a luminos-

ity of approximately 20 billion Suns, these figures imply a supernova rate of one every 28 years, a figure consistent with the number of remnants seen. This is roughly one-third the value that other recent studies suggest. (These numbers all assume that the Hubble parameter is 100; if it is only 50, then the rates are four times smaller.)

The Canadian astronomers noted several important advantages of using Evans' data for their study. His visual search techniques are more likely to detect supernovae near the cores of galaxies, inside regions normally overexposed on photographs. Furthermore, many photographic discoveries happen by chance and are not the result of a systematic search program such as Evans'. Also, his selection of galaxies was more uniform than those in some photographic surveys, which tended to concentrate on clusters that often lacked certain types of galaxies.

Faint Stars and Brown Dwarfs

Most of the stars visible to the unaided eye are truly luminous, shining many times more intensely than the Sun. But these are the exception rather than the rule in our galaxy. When a cloud of gas and dust collapses under its own gravitation, faint, low-mass objects far outnumber bright, massive ones in the resulting swarm of new stars. Lately, astronomers have begun to ask how low in mass this trend extends. In particular, how abundant are the elusive brown dwarfs, objects bulkier than Jupiter but not massive enough to ignite nuclear fusion in their cores?

Neill Reid (Royal Greenwich Observatory) reports in the April 15th *Monthly Notices* of the Royal Astronomical Society that this question is of more than just passing interest. When astronomers add up the mass from all the objects they see in our neck of the Milky Way, they find only half the amount needed to explain the observed motions of nearby stars. Among the few candidates for the "missing mass" that haven't been ruled out on observational or theoretical grounds are brown dwarfs below 0.08 solar mass (see the February issue, page 150).

For these "failed stars" to fill the bill, however, they must be plentiful. This is what we might expect if the relative number of stars continues to rise unabated as we consider smaller and smaller masses. But several recent studies have suggested that the birthrate declines beyond a peak near 0.25 solar mass.

Reid disputes the latter conclusion and presents tantalizing evidence that the relative number of new stars actually climbs toward the lowest luminosities and masses. The relation between stellar birthrate and mass traditionally has been determined from visible-light observations, he notes, but the faint *K* and *M* dwarfs at the low-mass end of the main sequence emit most of their energy at infrared wavelengths. Only if the infrared contribution to the total, or bolometric, luminosity is included can the corresponding mass be calculated accurately.

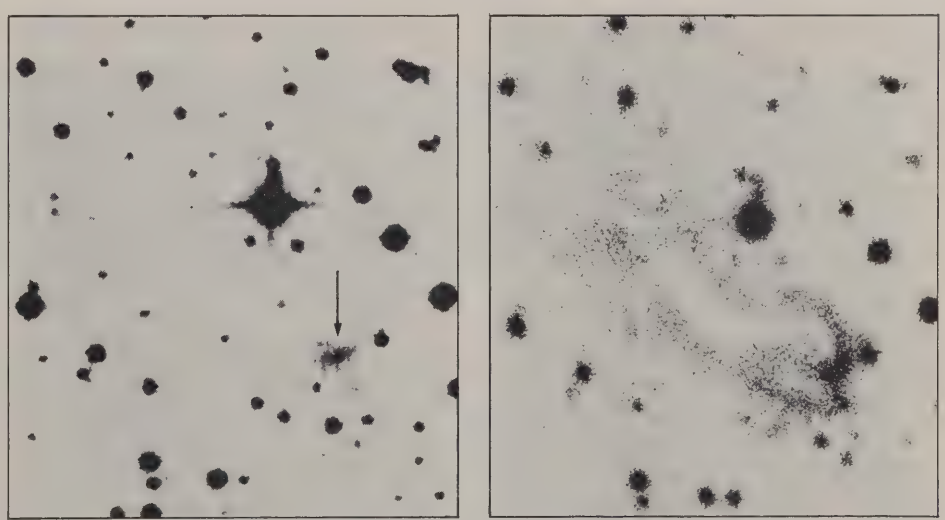
Adjusting previously published data accordingly, Reid found a new minimum in the stellar birthrate near absolute bolometric magnitude 12.5 (0.0008 solar luminosity) and a hint of a subsequent rise toward fainter objects. If the latter feature is real, it may delineate the boundary between true stars and substellar objects.

Reid points out that among the lowest-mass stars known, none displays any properties that clearly identify it as a brown dwarf. Astronomers have yet to find even one confirmed example of such an object (see the August issue, page 139). On the other hand, if the rising stellar birthrate for the dimmest stars is entirely due to substellar objects with masses near 0.04 Sun, they would neatly account for all the missing mass in the galactic disk. However, this scenario allows no leeway for objects of still lower mass. Additional searches for brown dwarfs, especially in the infrared, are clearly warranted.

Further theoretical work is also needed. In an article in the August 15th *Astrophysical Journal Letters,* Donald McCarthy, Jr., and Todd J. Henry (University of Arizona) show with direct infrared measurements that the mass, luminosity, and apparent age of the dim companion to nearby Gliese 623 (a 10th-magnitude dwarf in Hercules) seem incompatible with current models of low-mass stellar evolution, including some that Reid used. Perhaps the increasing pace of infrared observations, combined with refinements in theory, will soon enable astronomers to determine once and for all whether brown dwarfs really exist and what role they play in the dynamics of our galaxy.

Star-Forming Globule

Bok globules are dark, compact, interstellar clouds. Astronomers have long felt that these dense, sharp-edged blobs may be prime candidates for stellar nurseries, but evidence to support that view has been hard to come by. Now, however, D. J. King (Admiralty Research Establishment,



A faint red star lies in a comet-shaped Bok globule associated with the diffuse nebula IC 4628. In the blue-light negative image (*left*) the embedded stellar object is clearly visible (arrowed), along with a small amount of nebulosity. In the light of the red hydrogen emission line (*right*) the star is largely obscured by the globule's bright, complex rim. The cloud's long, light central "spine" is bordered by faint diffuse nebulosity. The embedded object is about 30 arc seconds from the brightest star here. South is up and east to the right in images by D. J. King, courtesy of the U. K. Schmidt Telescope Unit.

Great Britain) has found a globule containing what appears to be a pre-main-sequence star that has some properties of spectral class *F*. He notes that this close association is unlikely to be merely a chance encounter, and thus "globules, it would appear, can be sites of low-mass star formation."

The globule was detected by the Infrared Astronomical Satellite and is one of several involved with the very young ionized-hydrogen (H II) region IC 4628, an emission nebula which is itself related to the Scorpius *OB*1 association of hot, newly formed stars. King's blob and a number of its neighbors have a vaguely "cometary" shape — they are elongated, with dark cores and bright rims (see illustrations on the previous page).

The globules' "tails" all point away from the central region of IC 4628, indicating some physical connection. Both shock waves and the long-term action of ultraviolet light have been suggested as the cause of the unusual cometary shapes. In this case, however, spectra indicate that ionization by ultraviolet radiation, probably from hot stars in IC 4628, is presently the dominant process.

The embedded object probably lies close to the globule's surface and has some unusual properties. For one, it is extremely red, due in large part to strong emission lines from both the "star" and overlying nebulosity. In addition, there are no dark absorption lines, such as those that appear in the spectrum of a typical *F* star — or any other type, for that matter. However, such features come from normal photospheres, and may not arise on pre-main-sequence bodies that are enveloped in gas and dust and likely to be still contracting. Details can be found in the May 15th issue of the *Monthly Notices* of the Royal Astronomical Society.

Chewing on Gomez's Hamburger

In 1985 Arturo Gomez, an observer at Cerro Tololo Inter-American Observatory, discovered a curious object in southwestern Sagittarius. Only 3½ by 5½ arc seconds in size and shining at visual magnitude 14½, the patch of glowing gas is cut in two by a dark band. As the photograph at right shows, it bears a striking resemblance to a hamburger in a bun. Until recently the nature of this object was unknown.

Recent spectroscopic, polarimetric, and photometric studies of Gomez's Hamburger suggest that we are seeing a ring of hot dust, surrounded by a cloud of cooler dust, and illuminated by an embedded giant star of spectral type *A*. Maria Teresa Ruiz (University of Chile) and her coworkers interpret these facts in the scenario of an evolved star in the process of forming a proto-planetary nebula. Similar interpretations have been suggested for the famous Red Rectangle and Minkowski's Footprint, which, together with Gomez's Hamburger, comprise a class of double-lobed or bipolar nebulae.

These results were reported in the *Astrophysical Journal* for May 1, 1987.

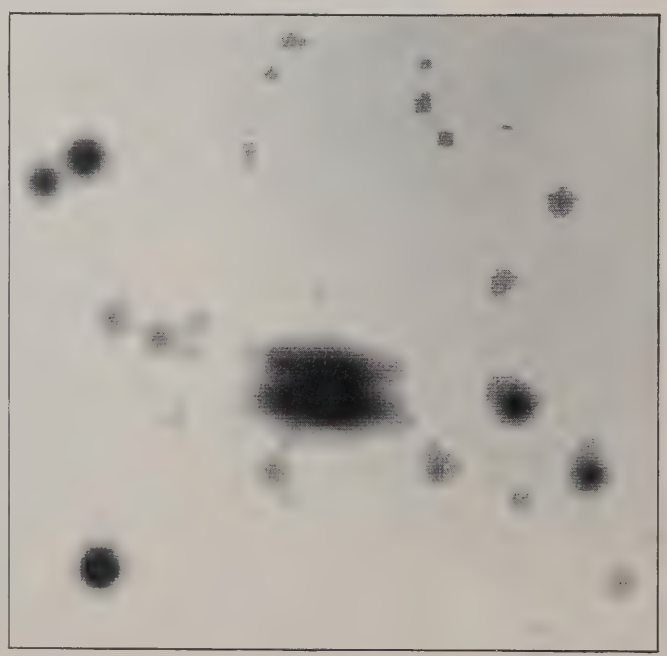
Scum on Triton's Seas?

Although Voyager 2's eagerly anticipated visit to Neptune is still some two years away, scientists already have ideas about what they will find at Triton, the larger of the planet's two known moons. The satellite, possibly as large as Saturn's Titan, is thought to have a substantial atmosphere (*S&T:* July, 1983, page 23). Even more surprising, two researchers have recently concluded that Triton's surface could be partially covered with a soup of ultra-cold liquid nitrogen and methane on which floats a froth of organic compounds.

Mona L. Delitsky (Jet Propulsion Laboratory, California Institute of Technology) and W. Reid Thompson (Cornell University) suggest in the May issue of the planetary-science journal *Icarus* that billions of years of cosmic-ray bombardment has transformed some of Triton's primordial nitrogen-methane slush into more complex organic molecules. The highest-energy cosmic rays could penetrate many dozens of feet beneath the nitrogen oceans, splitting chemical bonds and ionizing atoms. (Radiation from the Sun, some 2.8 billion miles away, is too weak to cause chemical changes and is absorbed by the atmosphere.)

The dominant by-product would be liquid ethane (C_2H_6), which would float on the surface in a layer several feet deep. The nature of other, more complex molecules would depend on the exact conditions of the sea's surface. No absolute characteristics of Triton are known, though the temperatures probably lie between 45° and 70° Kelvin. Delitsky and Thompson recommend further study of such low-temperature mixtures to see "what really does float on what, under which conditions."

The organic molecules could also easily account for the satellite's reddish hue, offering a tantalizing hint of what Voyager may find in August, 1989. Perhaps, Delitsky and Reid write, the spacecraft's cameras will "see plains of white and colored organic deposits and, maybe, the glint of a distant Sun reflected off a calm nitrogen sea."



Gomez's Hamburger (center) may be a planetary nebula in the making. This image in visual light has east at the top and north to the right. It was taken with a charge-coupled device on the 1.5-meter telescope at Cerro Tololo Inter-American Observatory and is courtesy Maria Teresa Ruiz.

ASTRONOMY EXPRESS

Pope Meets Angel. On September 14th, during his recent visit to Arizona, Pope John Paul II discussed plans for the 1.8-meter Vatican Advanced Technology Telescope (VATT) with mirror-making ace Roger Angel and colleagues. Steward Observatory director Peter Strittmatter told *Sky & Telescope* the Pope was "very interested in the project and knowledgeable about astronomy."

VATT, a joint project of Steward and Vatican observatories, will utilize a blank made several years ago in Angel's famous spinning oven. Figuring to f/1 continues at the University of Arizona's Optical Sciences Center using a polishing machine with a revolutionary computer-controlled deformable lap. According to Strittmatter, "Nobody has ever polished an f/1 primary of this size before. VATT will be the prototype for a family of fast 8-meter-class telescopes."

The Vatican Observatory has based a sizable contingent of astronomers in Tucson, Arizona, since the early 1980's. VATT, to be located on Mount Graham if the U. S. Forest Service grants permission, will be its principal observing tool when completed in two years.

Galileo Addition? A second ultraviolet spectrometer may be added to NASA's Galileo spacecraft, according to project scientist Torrence Johnson. The 10-pound detector is actually a spare piece of Voyager hardware, and scientists are now determining whether the installation can be made before launch (now set for November, 1989). The add-on spectrometer would observe the Jovian system from 400 to 1800 angstroms, much of which is outside the range of Galileo's existing ultraviolet instrument (1150 to 4300 angstroms). A description of the mission appears in the April issue.

Phosphorus among the Stars. Astronomers have for the first time identified an interstellar molecule containing phosphorus. The discovery was made through radio observations of the interstellar medium and giant star-forming molecular clouds in Orion, Aquila, and Sagittarius. Researchers Barry E. Turner (NRAO) and John Bally (Bell Laboratories) found the spectral signature of phosphorus nitride (PN) using antennas in Arizona and New Jersey. Lucy M. Ziurys (University of Massachusetts, Amherst) independently made similar observations and arrived at the same result. Conventional chemical models cannot explain the surprisingly high abundance of the molecule.

"Besides the astrophysical interest of phosphorus," Turner told *Sky & Telescope,* "this element plays a key role in DNA and other life processes. It may be that critical initial stages of prebiotic chemical evolution can transpire in interstellar clouds long before 'warm little ponds' form on a planet within the life zone surrounding an *F* or *G* star." Details appear in the October 1st *Astrophysical Journal Letters.*

New Solar Observatory Plans. Researchers hope that NASA will allow a 1-meter solar telescope, initially designed as part of Spacelab, to become a free-flying satellite. The future of the High-Resolution Solar Observatory (HRSO) has been in doubt for some time — the backlog of shuttle experiments makes multiple flights of the telescope unlikely. The HRSO Science Working Group, with support from NASA headquarters, announced early in September their wish to expand the project. The satellite, if approved, will during its five-year lifespan examine the Sun with a resolution of 0.125 arc second. Enthusiasm for the mission grows because a free-flying satellite would offer room for new extreme ultraviolet or X-ray instruments, perhaps provided at little or no cost to the United States by international partners. NASA has already invited West Germany to contribute to the project.

Palomar Schmidt To Be Renamed. The 48-inch Schmidt telescope at Palomar Mountain will soon be renamed the Oschin Telescope, to honor the donation of $1 million to the California Institute of Technology. The gift from Mr. and Mrs. Samuel Oschin will help finance astronomical research at Palomar.

The Infinite Series. A three-year run of quarterly science shows, collectively called *The Infinite Voyage,* will premiere on PBS on October 28th (later on some commercial stations). The first episode, "Unseen Worlds," will reveal the breakthroughs in scientific imaging from atomic to galactic scales.

Submillimeter Dish at ESO. The latest addition to the European Southern Observatory's (ESO) growing collection of astronomical instruments is the 15-meter SEST, or Swedish-ESO Submillimeter Telescope (*S&T:* August, 1985, page 119). Its high, dry location at La Silla, Chile, plus a reflector figured to an accuracy of 50 microns, enables SEST to operate at wavelengths as short as 0.8 millimeter. The telescope (see below), built jointly by Sweden and ESO, will be in great demand because it is the only large submillimeter dish in the Southern Hemisphere. The SEST antenna is identical in design to those for the three-telescope interferometer presently under construction on the Plateau de Bure in the French Alps.

The Orion nebula is a huge cloud of gas, mostly ionized hydrogen. It glows under the action of ultraviolet light poured out by the hot, luminous *O* and *B* stars in the Trapezium cluster at its center. This one-hour exposure was made in the light of the red hydrogen-Balmer line by Massimo Tarenghi and C. Madsen with the 3.6-meter telescope of the European Southern Observatory. South is up and east to the right. Illustration courtesy ESO.

The Spectacular O Stars

James B. Kaler, University of Illinois

HOTTEST, BLUEST, brightest, most massive, and rarest are superlatives that describe *O* stars. Unfortunately, the last of these qualities means that these luminaries are relatively unfamiliar; none are close enough to shine at 1st magnitude, and only four are 2nd. However, this quartet does contain two familiar objects, Delta and Zeta Orionis, the stars at either end of Orion's Belt. Both are binaries. The first contains an *O*9 main-sequence component that is coupled to a *B*0 giant companion. The second pair of stars is dominated by a bright *O*9.5 supergiant.

The other two 2nd-magnitude stars are well known to observers in the Southern Hemisphere. Zeta Puppis is a very luminous *O*5 supergiant, while the binary Gamma^2 Velorum contains an *O*7.5 star. The latter is remarkable for having a brilliant, unresolved Wolf-Rayet component (more about Wolf-Rayets later) as well as four visual companions; the system is a favorite sight for observers with small telescopes. Both Zeta Puppis and Gamma^2 Velorum lie within the Gum nebula, a vast supernova remnant. The northern celestial hemisphere is less fortunate than the southern when it comes to prominent *O* stars. The brightest example north of the celestial equator is 4th-magnitude Xi Persei (*O*7).

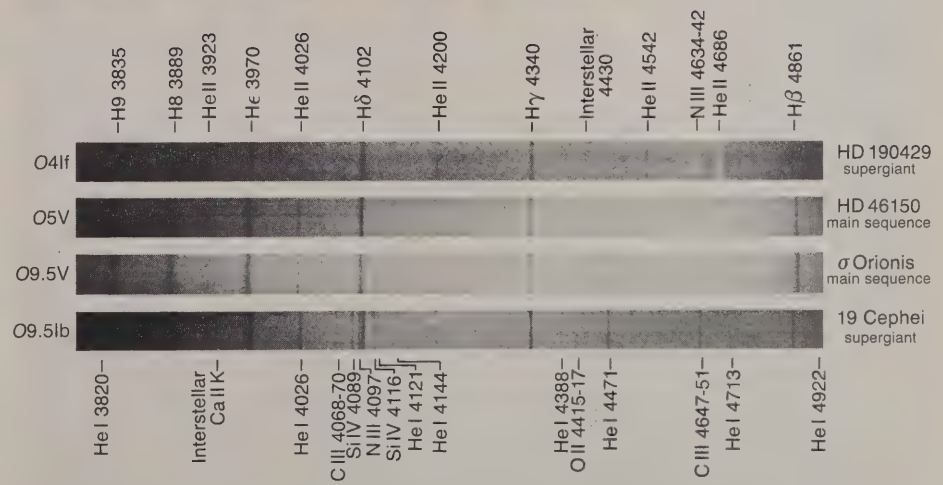
Through a telescope the *O* stars cut a much more impressive figure, for they energize the bright gaseous nebulae that provide so many of the sky's showpieces. The best known of these stars is Theta^1 Orionis C, the brightest member of the Trapezium and the powerhouse that lights up the Orion nebula. Young *O* stars and the accompanying clouds of gas from which they were born dominate the spiral arms of galaxies and trace regions of active star formation.

The most luminous known star of this type is HD 93129A, an extraordinary 7th-magnitude *O*3 supergiant near the spectacular variable Eta Carinae. In the Hertzsprung-Russell diagram on page 468, HD 93129A appears to be fainter than II Cygni No. 12, the brightest *B* star. This is true for visible light, but not when the output from *all* wavelengths is considered.

Most of a hot star's radiation is in the invisible ultraviolet, so its visual magnitude is misleadingly faint. To get the true brightness we have to add a so-called bolometric correction. For *A*0 supergiants this increase is only −0.3 magnitude, but at *B*0 it amounts to −2.7. At *O*3, the hottest class now recognized, the correction is *−4*; such a star gives off 40 times more energy than its visual magnitude indicates! (Very red stars also have large bolometric corrections, for most of their radiation is in the invisible infrared.)

In total energy output HD 93129A may be the most brilliant star in the entire Milky Way. It is nearly one-half magnitude brighter than II Cygni No. 12 and

This unique nebula in Canis Major was produced by a very hot and luminous Wolf-Rayet star lying near a cloud of interstellar matter. The rare Wolf-Rayets, which are related to stars of spectral type *O*, are losing mass at tremendous rates by means of powerful stellar winds. In this case the wind has accelerated the surrounding gas to an enormous velocity and has produced a visible shock front — a blue bubble blown in space. Photograph by David F. Malin with the 153-inch Anglo-Australian Telescope.



Comparisons among *O* stars. Neutral helium (He I) is weaker and the ionized form (He II) more intense in the hotter subtypes (upper two spectra) than in cooler objects. In the supergiant HD 190429 the He II feature at 4686 angstroms is in emission, so the star is classified as type Of. From *An Atlas of Representative Stellar Spectra* by Yasumasa Yamashita, Kyoji Nariai, and Yuji Norimoto.

more than one magnitude more luminous than any red supergiant known. Similar beacons are seen in the Large Magellanic Cloud's Tarantula nebula.

In their most spectacular form, *O* stars provide us with supernovae. Stars too massive to evolve quietly into white dwarfs are doomed to explode violently. Supernova 1987A probably started its life as an early (hot) main-sequence *O* star of about 15 to 20 solar masses.

In spite of their rarity, these splendid objects are intensively studied because of their often extreme behavior and properties. The high rate at which they evolve, along with their ability to transmute, disperse, and stir up matter, makes them of the utmost importance in the evolution of galaxies.

SPECTRA

As with type *M,* classification at *O* is open-ended, and as we find hotter stars we may adopt additional subtypes. Originally the system began at *O5*, which corresponds to a surface temperature of about 40,000° Kelvin; now it starts at *O3*, which is close to 50,000° K.

Unlike the classification of cooler stars, type *O* requires the use of emission lines. These stars are so energetic and luminous that many of them shed matter fast enough to form substantial circumstellar shells, which give rise to the bright emission lines in their spectra.

O stars with hydrogen emission are called *O*e. However, a much more significant variety of bright-line object is dubbed *O*f. These objects show bright lines of ionized helium (He II) at 4686 angstroms and doubly ionized nitrogen (N III) at 4634 and 4640. A prominent example is the star Zeta Puppis.

There is no sharp division between *O*f stars and those showing only absorption spectra. An intermediate type is *O*(f), which has bright N III but only weak emission or absorption in the 4686-angstrom He II line. Another is *O*((f)), which also has nitrogen emission but strong He II absorption.

As we move to hotter and hotter *O* stars, the He II dark lines become more prominent. At the same time, neutral helium (He I) gradually disappears, while the hydrogen Balmer lines slowly fade, though they remain stronger than He II. All these effects are due to increasing temperature.

The subtypes of *O*-star classification are most commonly based on the ratio of He II to He I line strengths, with Si IV (triply ionized silicon) providing useful spectral features for giants and supergiants. However, we can't use the prominent He II line at 4686 angstroms, for it can be in emission. Instead we must employ the Pickering series of ionized helium (an analogue of the infrared Brackett series of neutral hydrogen), which is always in absorption.

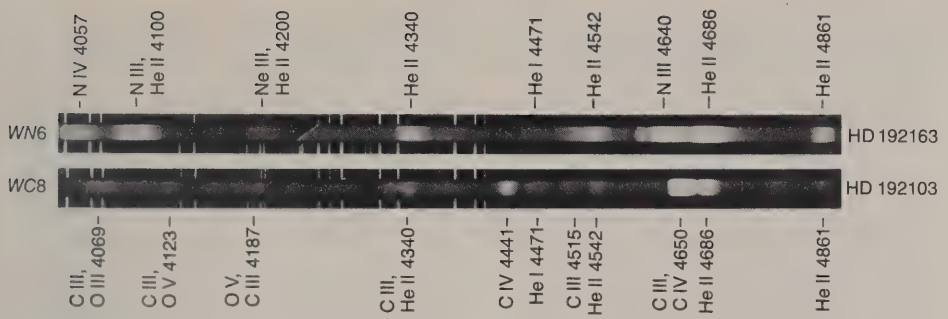
While hydrogen lines are not good indicators of absolute magnitude in *O* stars, there are a variety of useful alternatives. The 4686 He II absorption feature weakens with increasing luminosity until it disappears and is converted into an emission line. For middle and late (cool) *O* subtypes, the Si IV lines at 4089 and 4116 angstroms in the visible and 1394 and 1403 in the ultraviolet grow stronger among the more luminous stars.

WOLF-RAYET STARS

Perhaps the most "extreme" *O* stars are those few that exhibit numerous strong and broad emission features (see illustration on page 467). These Wolf-Rayets (original spectral class *WR* or *W*) are named after two astronomers at Paris Observatory who discovered the first examples in 1867. Emission lines dominate their spectra; whether absorption lines occur too is debatable. These very hot, luminous stars are losing mass at such a furious rate that about all we can see in their spectra are indications of outflowing gas.

Wolf-Rayets are now divided into two parallel spectral sequences, the *WC*'s with prominent carbon emission and the *WN*'s with nitrogen. Although the *WC* stars show some nitrogen features, and the *WN* some carbon, the partition between the

The Lagoon in Sagittarius is one of the largest and brightest nebulae in the sky. Its emission-line spectrum derives from ultraviolet light emitted by embedded *O* and early *B* stars. Photograph by David F. Malin with the United Kingdom Schmidt telescope.



These two Wolf-Rayet spectra show strong and broad emission lines of nitrogen (top) or carbon (bottom), among other elements. University of Michigan photographs from *Astrophysics: Nuclear Transformations, Stellar Interiors, and Nebulae* by Lawrence H. Aller.

two is clean and clear — there are no intermediate cases. Both varieties show helium but little or no hydrogen, while the *WC*'s also include oxygen. We are probably looking at fundamental chemical differences, with some stars rich in carbon and others rich in nitrogen.

Each Wolf-Rayet type is subdivided, *WN*3 to *WN*8 and *WC*5 to *WC*9, based on high-excitation features. Typical indicators are the presence and strength of N V and N III in early and late *WN*'s, respectively, and the ratio of C IV to C III for the *WC* variety. The numerical subclasses are not consistent with each other and are not parallel to their *O*-type counterparts.

There appear to be intermediate types between normal *O* stars and the Wolf-Rayets. These marginal cases have normal absorption spectra but enhanced amounts of carbon and nitrogen, and so they are called *OC* or *ON*, respectively.

The temperatures of Wolf-Rayet stars are uncertain since we are dealing with gas under peculiar conditions. Analyses of emission lines give values of 30,000° to 50,000° K, but the continuous spectrum yields much cooler temperatures, in the vicinity of 20,000° K.

MASS LOSS

Stars at the extremes of the spectral sequence exhibit powerful gas outflows. At the cool end, *M* giants and supergiants are often enmeshed in thick, dusty cocoons of their own manufacture. At the other end, the enormous luminosities of very hot objects cause them to expel material as well. *O*f varieties in the ultraviolet, and *WR* types in the visible as well as the ultraviolet, display strong "P Cygni" line profiles characteristic of outrushing gas. These features are bright emissions bounded on their blue edges by dark absorptions.

The P Cygni lines in the ultraviolet spectrum of the *O*3 star HD 93129A are illustrated on page 469. The maximum speed of the outward-flowing gas can be found from the wavelength of the blue edge of the absorption feature, which is displaced from the center of the emission feature by the Doppler shift as absorbing material rushes towards us. Typical speeds derived in this way are 2,000 to 3,000 kilometers per second. In the case of HD 93129A the blue absorption edge has been blueshifted from 1550 to 1525 angstroms, corresponding to a remarkable expansion velocity of 4,800 km per second.

Mass-loss *rates* are much more difficult to determine. First we must calculate the number of ions producing a line, which is very complicated to do for expanding, high-density atmospheres. Then we have to convert this information into the total amount of gas involved, which compounds the difficulty since not all kinds of atoms and ions produce observable lines.

Our best estimates indicate mass-loss rates of 10^{-5} solar mass per year for type *O*f, and even greater for *WR* stars. Such values are enormous compared to that of the Sun, whose solar wind carries away only a minuscule 10^{-14} of its mass each year. This hemorrhaging of material from hot, massive stars plays a significant role in their evolution.

Radio and infrared telescopes have detected the ejected material as tiny clouds around some *WR* stars, and mass-loss rates determined from these observations agree with those derived from spectra in visible light. We might also expect to see direct visual evidence of such enormous mass loss rates, and indeed we do. A number of *WR* stars — and even a few *O*f's — are surrounded by nebulae that show emission-line spectra and can be quite large. Some of these "ring nebulae" are highly enriched in nitrogen and helium, confirming the abundance anomalies of their parent stars. They are formed by the interaction of outflowing gas with the interstellar medium; though they may look like planetary nebulae, the resemblance is entirely superficial.

Astronomers now believe that very high mass-loss rates can convert one kind of star into another and that the Wolf-Rayet phenomenon follows the *O*f state. There are other possible *WR* precursors as well: P Cygni, Eta Carinae, S Doradus, and the enigmatic Hubble-Sandage variables (luminous stars with *F*-type spectra in the spiral galaxy M33).

The masses of *WR* stars average some 20 Suns. This is on the low side compared to their *O*-type counterparts and suggests they have lost a lot of material. The wide range of masses for Wolf-Rayet stars — from 10 to 50 times that of the Sun — indicates that these objects are in a variety of evolutionary states. At one time Wolf-Rayets were probably ordinary main-sequence *O* stars with masses of perhaps 50 Suns. But now we see them with their outer layers peeled away to expose material enriched in carbon and nitrogen by nuclear fusion.

The *WN* and *WC* stars may represent successive evolutionary stages with different internal layers now exposed. We suspect that *WN* stars develop into *WC*'s as they continue to shed matter, but the expected mass difference between the two types has not been confirmed. On the other hand, the *WN* and *WC* sequences may *not* be related but result from different initial conditions such as the original mass. A complicating factor is that many *WR* stars are in binary systems with a close, often *O*-type, companion that may influence or even drive mass loss.

STELLAR ASSOCIATIONS

A dominant feature of *O*-star life is a tendency to occur with early *B* stars in loose groupings known as *O* or *OB* associations. A typical system contains several dozen stars, the majority of type *B*, within a space as small as a few light-years across or as large as hundreds. At the center of the association generally lies an open cluster containing a few *O* stars.

The naming of associations is confusing. Some carry NGC numbers or open-cluster designations. For many others an old and commonly used scheme employs a Roman numeral attached to a constellation name. One example is II Persei, which contains the naked-eye stars Xi (*O*7e), Zeta (*B*1), and Omicron (*B*1) Persei. The nomenclature was revised in the 1960's, and II Persei became Perseus *OB*2, while I Cygni was renamed (and renumbered) Cygnus *OB*3! The best known of these *OB* groupings are the huge, nearby Scorpius-Centaurus association (it has no other name) and Orion *OB*1, which includes the Belt stars.

Associations are young, ephemeral, and

related to stellar birth. Unlike open clusters, they are not bound together gravitationally but are expanding and dispersing — the largest, therefore, are also the oldest. Young, compact associations are frequently found near their parent clouds of interstellar gas and dust. Perseus *OB*2, for example, is related to the California nebula, Monoceros *OB*2 to the Rosette, and Monoceros *OB*1 (NGC 2264) to a huge, bright complex some 5° north of the Rosette. Wolf-Rayet stars are also found in associations, providing yet another connection with the *O* stars.

DIFFUSE NEBULAE

Among the loveliest and most fascinating manifestations of the *O*-star family are the diffuse nebulae, or H II regions. The best known is the Orion nebula (M42), while other examples are the Lagoon (M8), Trifid (M20), Omega (M17), Rosette, North America (NGC 7000), and Eta Carinae. All lie in the star-forming plane of the Milky Way. These nebulae glow with emission-line spectra and are energized by ultraviolet light from the *O* and early *B* stars embedded in them.

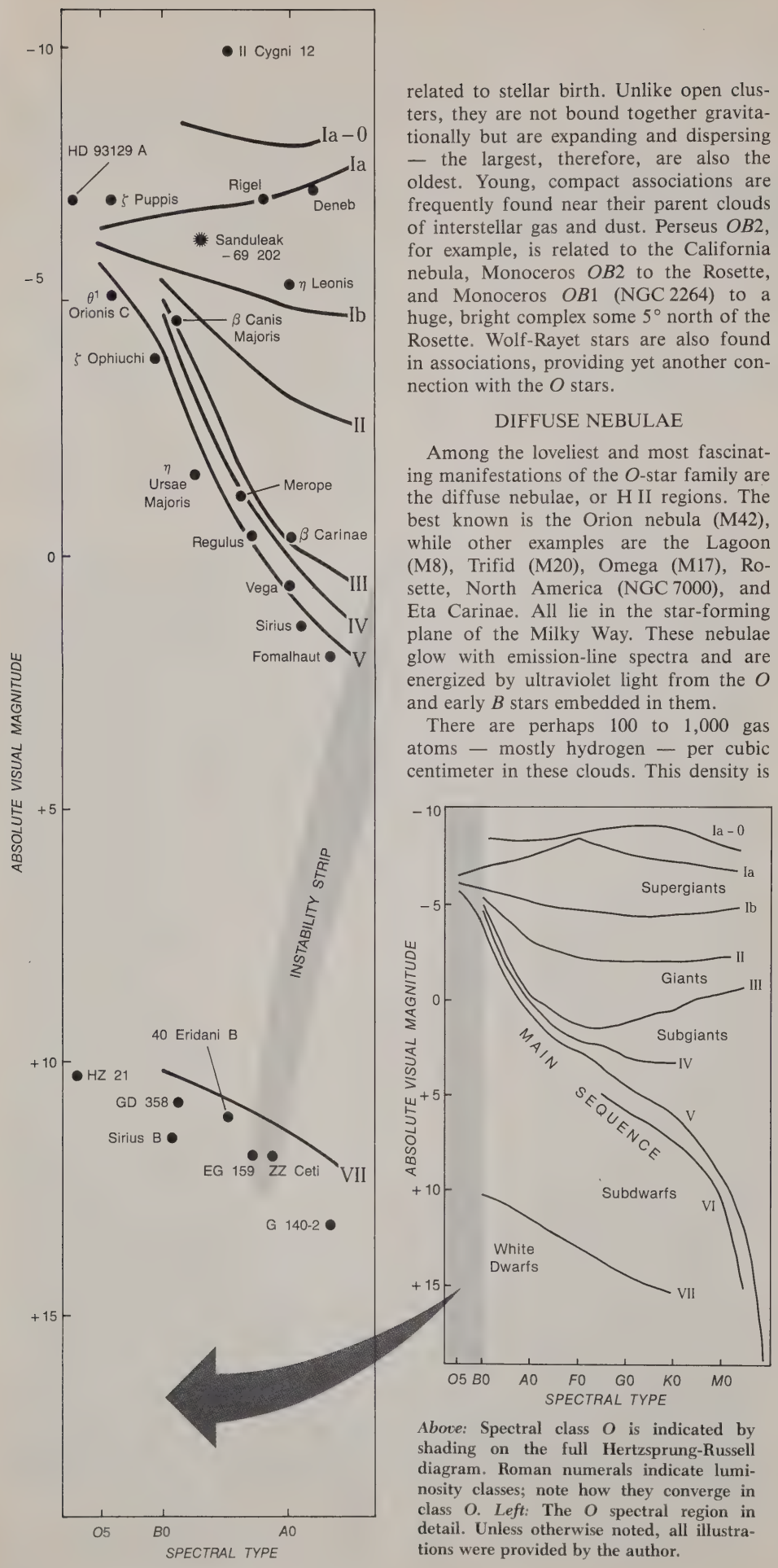
There are perhaps 100 to 1,000 gas atoms — mostly hydrogen — per cubic centimeter in these clouds. This density is high compared to the interstellar average of 1 atom per cubic centimeter but very much lower than the best vacuum obtainable on Earth. Since collisions are infrequent, the atoms' orbital electrons will be in their lowest energy, or ground, state most of the time. Nevertheless, eventually such an atom will be struck by an energetic, ultraviolet photon from a nearby hot star and lose its electron as a result.

After wandering in space for some time, the liberated electron will eventually encounter a proton and recombine with it to form a neutral hydrogen atom. The electron may land in any orbit at all. From there it might jump directly to ground level, releasing an ultraviolet photon, or it might cascade through several intermediate levels on the way down, radiating a variety of wavelengths as it goes. A jump from the third to the second level, for example, produces the red Balmer line (Hα), while that from the fourth to the second gives rise to the blue Balmer feature (Hβ), and so forth. Hα is by far the strongest line, which is why nebulae usually appear red in properly exposed color photographs.

The competition between ionization by photons and recombination is such that the gas is highly ionized and consists largely of a sea of free protons and electrons. Typically fewer than one percent of the atoms are neutral. An *O* star will fully ionize the surrounding gas out to the distance at which all of its ultraviolet photons are absorbed. At that point, which may be several light-years from the star, the material suddenly becomes neutral. This picture was first outlined by the late Bengt Strömgren, and the ionized volume is called a *Strömgren sphere*. The Rosette nebula is a fine example. Yet, since the gas distribution in space is usually anything but uniform, nebulae are often far from spherical.

The concept of temperature loses some of its usual meaning in regions where the gas density is very low. The so-called electron temperature of a nebula relates only to the speeds of its atoms and electrons. Typical values of this quantity are about 10,000° K. That is, the particles in a nebula move at speeds typical of those found in the atmospheres of *A* stars, which have roughly that temperature. However, nebulae are not perfect radiators ("black bodies") and radiate at an intensity much less than that appropriate to this temperature. As a result, a nebula has a much lower surface brightness than an *A* star.

Many other elements besides hydrogen, most notably helium, produce similar types of recombination emission. How-



Above: Spectral class *O* is indicated by shading on the full Hertzsprung-Russell diagram. Roman numerals indicate luminosity classes; note how they converge in class *O*. *Left:* The *O* spectral region in detail. Unless otherwise noted, all illustrations were provided by the author.

ever, some of the strongest nebular lines *cannot* be explained in this manner and defied identification until about 1930. These are "forbidden" lines, the best-known of which are due to doubly ionized oxygen and are written "[O III]." They can give some nebulae a greenish cast when viewed directly, for the eye has poor sensitivity to red hydrogen light.

These features arise from a pair of long-lived, or "metastable," states just above ground level. Atoms in nebulae can stay in these metastable states for tens or even hundreds of seconds before they spontaneously emit a photon and return to ground level. This situation is in marked contrast to the mere 10^{-8}-second lifetime for an upper level of the hydrogen atom. In the laboratory, where the gas density is unavoidably high, forbidden lines occur with much lower probability than lines formed via other processes, so they cannot be seen. But in nebulae, where the density is low and the total mass high, conditions are just right.

Well before the discovery of their origin, the green forbidden lines were thought to be produced by "nebulium," an element that had not been found on Earth. Similar emissions, such as [Ne III] and [O II], occur in the ultraviolet. In the red we find pairs of [N II] and [S II] lines near Hα.

Nebular spectra are simple to analyze, and we can use them to determine the temperatures, densities, and chemical compositions of interstellar clouds. Furthermore, the atoms we can detect in this way are often just those most difficult to study by means of stellar absorption lines: helium, oxygen, and neon are good examples. The study of nebulae reveals the variation in chemical composition within the disk of our Milky Way galaxy and across the faces of others, allowing us to probe galactic evolution and the mechanisms of star formation.

INTERSTELLAR LINES

The bright H II regions are but one way in which *O* stars reveal the interstellar medium. Another is the harboring of *interstellar* absorption lines in *O*-star spectra. In principle, all dark gas clouds between us and a star will superimpose their absorption spectra on starlight that passes through them. Unfortunately, many stars are not behind enough interstellar material to build up strong lines. Worse, these features come from states of low ionization and excitation and are lost amid the similar and overpoweringly complex spectra of cool stars.

In the hot *O* and *B* types, however, the competing lines have disappeared and the interstellar absorption shows well against the simple spectral backgrounds. Moreover, *O* stars are very luminous, distant, and lie in the galactic plane where most of the gas also resides. The first detection of an interstellar line, one of singly ionized calcium, was made in 1904 in the spectrum of Delta Orionis.

Other interstellar lines, such as from sodium and the CN and CH molecules, have also been identified in spectra taken by ground-based telescopes. And from orbiting telescopes such as Copernicus and the International Ultraviolet Explorer we have obtained extraordinarily good data on ultraviolet interstellar lines. In the region from 1000 to 3000 angstroms there are numerous features due to carbon, nitrogen, oxygen, silicon, many common metals, and molecular hydrogen (see the spectrum of HD 93129A below). The interstellar gas shows a remarkable depletion of certain types of atoms, notably those heavier than sodium. Apparently these elements, along with others such as carbon, have been drawn out of the gas during the formation and growth of interstellar grains.

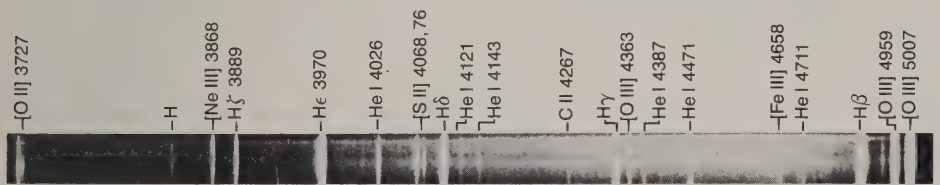
THE TIP OF THE MAIN SEQUENCE

The absolute number of stars drops precipitously as we proceed to hotter and hotter types. About 70 percent of all main-sequence luminaries are dim, red, low-mass, *M* dwarfs. Only 0.1 percent are *B* stars, while the *O* variety contributes only an amazingly minuscule 0.00004 percent!

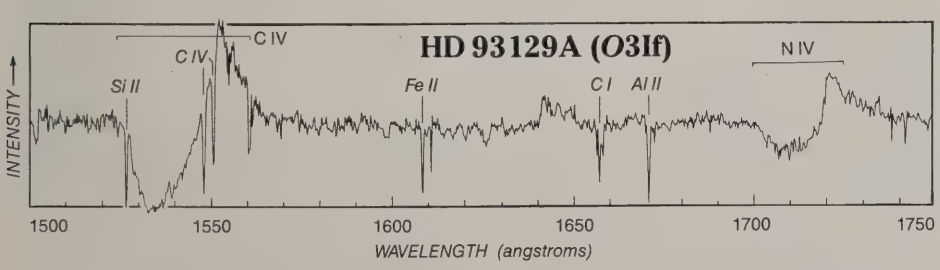
Apparently nature prefers to create low-mass stars, though we have no idea why. The lowest mass of an *M* dwarf is about 8 percent that of the Sun; below that value thermonuclear fusion cannot be sustained. What about the other extreme? What are the most massive stars? We are still not sure, but they are almost certain to be found among the brilliant, very rare, *O*3 objects. Determining the mass of these luminaries is very difficult; the best estimates hover around 120 Suns.

Among the probable heavyweights are HD 93129A and HD 93250, both in the extraordinary Eta Carinae nebula. Also in the running are the stars that light the gigantic Tarantula nebula (30 Doradus) in the large Magellanic Cloud. Near the center of this glowing cloud lies Radcliffe 136a (HD 38168), which was once thought to be a single body with a mass as great as 1,000 Suns. However, it has recently been shown to be a tightly compacted cluster of *WR* and early *O* stars.

With the *O* stars we have reached what we think is the top of the main sequence. However, the members of this class are so rare, and examples so distant, that our ignorance of these spectacular but short-lived bodies is vast. The study of stellar spectra may be more than a century old, but it is still remarkably wide open for exploration.



This spectrum of the Orion nebula shows a wide variety of recombination and forbidden emission lines, the latter denoted by square brackets. This spectrogram was taken with a prism, so the wavelength scale is not linear as it is with a diffraction grating. Lick Observatory spectra from an article by A. B. Wyse in the *Astrophysical Journal*.



The ultraviolet spectrum of HD 93129A, perhaps the most luminous star in our Milky Way galaxy. Lines due to N IV and C IV show strong P Cygni profiles — emissions with absorptions on their blue (short-wavelength) edges. The sharp absorption lines labeled in italics are due to interstellar gas between us and the star. Adapted from the *International Ultraviolet Explorer Atlas of O-Type Spectra from 1200 to 1900 A* by Nolan R. Walborn, Joy Nichols-Bohlin, and Robert J. Panek.

James B. Kaler studies planetary nebulae and their central stars. His book, Stars and their Spectra: An Introduction to the Spectral Sequence, *will be published by Cambridge University Press.*

GONG: To See Inside Our Sun

John W. Harvey, James R. Kennedy, and John W. Leibacher, National Solar Observatory

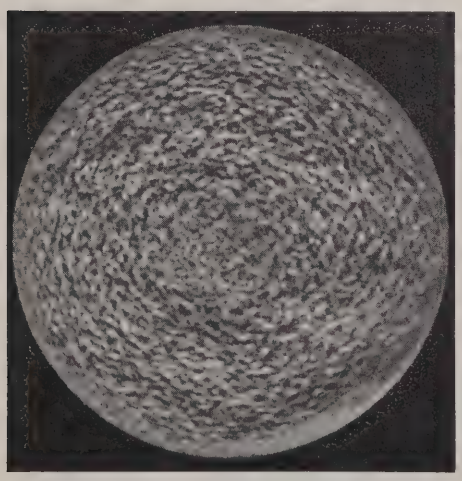
THE SUN, the nearest star to Earth, offers astronomers a unique opportunity to study stellar processes. While other stars appear only as dancing dots, or even blurred blobs, the Sun reveals its surface features in exquisite detail. Moreover, its brilliance provides ample light for the most exacting spectrographic studies of its chemical constituents, magnetic fields, and surface motions.

Yet, despite such detailed information, we know surprisingly little about what happens inside the Sun. All the radiation we detect on Earth comes from the outermost layers of our star and provides only indirect information about processes occurring beneath the Sun's visible surface.

To overcome this limitation, the National Solar Observatory (NSO) has initiated a major project that promises to provide dramatic new knowledge about the internal structure and dynamics of the Sun. This world-wide program — called GONG for Global Oscillation Network Group — will permit scientists to study the depths of our star's interior by means of its naturally occurring oscillations.

A STARTING POINT

Billions of years ago the tremendous pressure exerted on the gas in the Sun's core, caused by the crush of the gravitation of its own overlying layers, raised the temperature to a level where thermonuclear burning of hydrogen into helium could begin. This process continues today and is thought to be confined to the central 20 percent of the Sun.



The Sun's surface is in constant up and down motion as this "velocity image" shows. Regions moving toward us are light and those receding are dark. The mottled appearance is due to the combined effect of millions of different oscillation modes and random motions. Photograph courtesy Big Bear Solar Observatory.

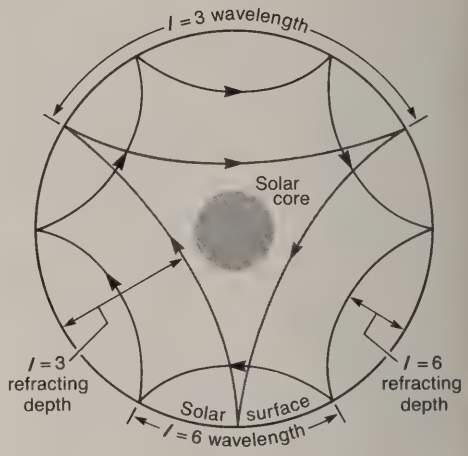
Energy escaping from the core in the form of radiation heats the overlying region that extends outward another 50 percent of the solar radius. In the outer 30 percent, radiation is no longer the most efficient means of transporting energy. Here huge convection currents, formed by hot material rising and cool material sinking, take over and transport heat outward. Near the Sun's visible surface, or photosphere, these large-scale vertical flows spawn a multitude of smaller scale currents that produce the granular surface visible in telescopes.

Unfortunately, this simple view may not be correct. Our understanding of the Sun's interior is based on inferences from computer models, which rest on measurements of a relatively few solar characteristics. If we are to understand our star, we need a far more detailed picture. Many questions remain. For example, *exactly* how large are the convective and radiative regions? How does the internal temperature vary with depth? Does the Sun's structure change systematically over the 11-year solar cycle, or even longer periods?

The solar model outlined above was derived on the assumption that the Sun's rotation and other internal motions (except convection) can be neglected. But our star does rotate, and since it is a gaseous body its various parts are free to spin at different rates. We know that the equator rotates faster than the poles, and the interior may well spin at a rate unlike that at the surface. These relative motions will perturb the Sun's structure and create a picture different from the simple one derived from static models.

The Sun is also home to intense magnetic fields that must obey specific rules in the hot, ionized gases. Magnetic effects, like those involving rotation, are neglected in standard solar models.

The list of unanswered questions goes on and on. For example, hydrogen and helium are the most common elements in the universe, yet their actual abundance ratio inside the Sun — a vital parameter — is unknown. Another example is the infamous solar neutrino puzzle, which has vexed physicists for 20 years. Why do nuclear reactions appear to yield only a third the number of neutrinos expected?



Sound waves in the Sun, like seismic disturbances in the Earth, do not travel in straight lines. The increasing speed of sound toward our star's center refracts inward-traveling waves outwards, whereas the Sun's surface reflects outward-traveling waves back in. Ray paths for two fundamental modes (characterized by their *l* values, the number of times they encounter the Sun's circumference) are shown here. Note that the longer the wavelength the deeper a wave can penetrate into the Sun. All illustrations supplied by the authors unless stated otherwise.

The helium and neutrino problems are coupled in the minds of astrophysicists. Their computer models simulating the Sun's interior attempt to balance the weight of solar gases against the thermal pressure produced by nuclear fusion reactions. The aim is to produce a model star with the same radius and energy output as the Sun.

Consider this. The core temperature of a star depends on how much helium is present — the purer the hydrogen, the hotter the reaction. Now, nuclear physicists know that the production of neutrinos is very sensitive to temperature; the hotter the reaction, the more neutrinos are produced. Thus, to account for the Sun's apparently low neutrino production one might logically suppose a relatively high

concentration of helium and a low concentration of hydrogen.

Although this reasoning solves the neutrino problem, it doesn't work in practice. If the core is cooled this way, both the calculated radius and luminosity of the star become unreasonable compared to the real Sun. Many efforts have been made to adjust various models to account for all of these factors simultaneously, without any clear success. It may be that our picture of solar structure is wrong, or perhaps it is our understanding of nuclear physics, or maybe we are just fuzzy on the quantum mechanics of neutrinos.

HELIOSEISMOLOGY

Since the early 1960's solar physicists have puzzled over a phenomenon known as the "five-minute oscillation." The Sun seems to be undergoing a series of mechanical pulsations. At the surface, they appear as radial displacements that imprint Doppler shifts on solar spectral lines. These shifts oscillate through a blueward-redward cycle with a dominant period of about five minutes.

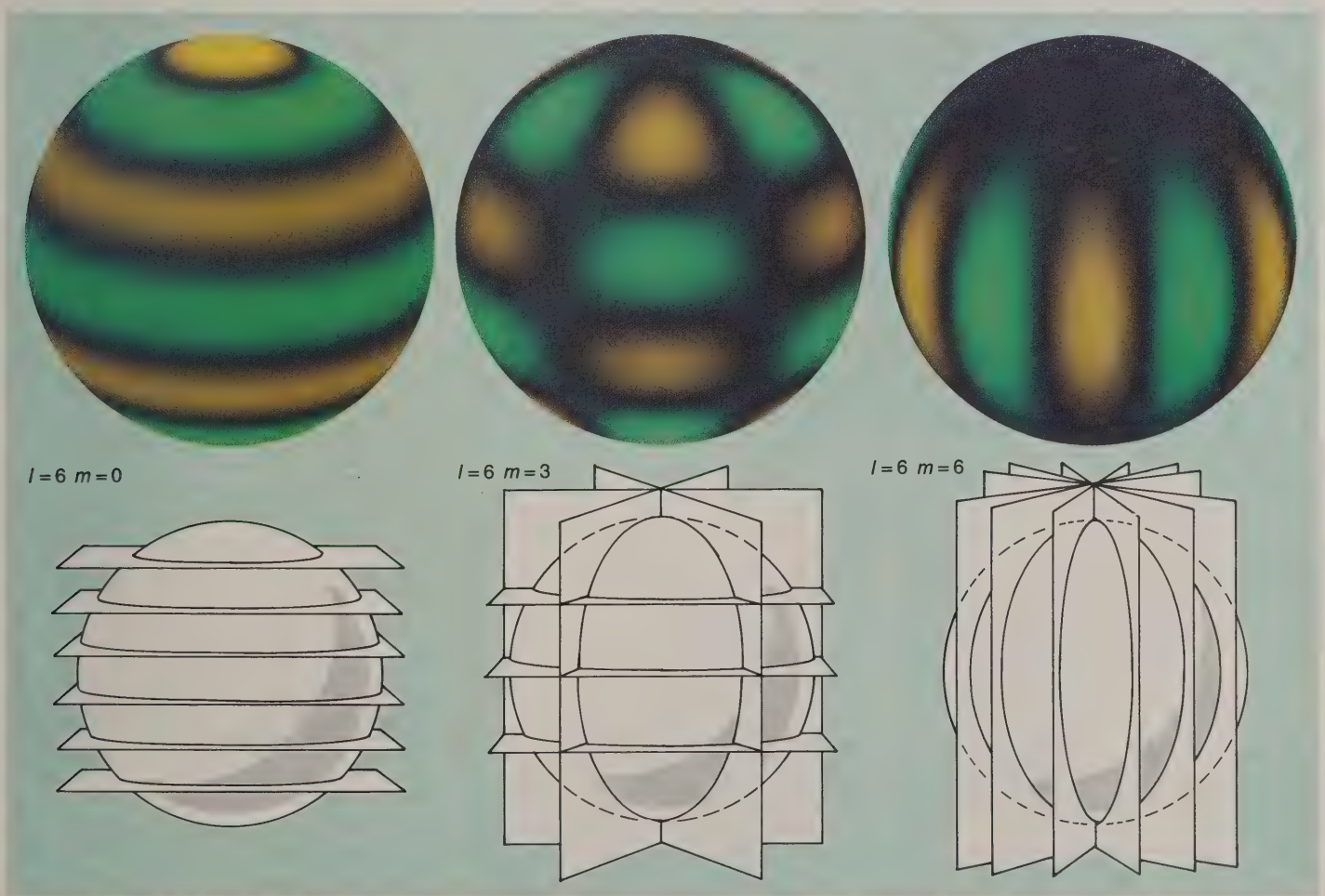
This effect can be observed, for example, by viewing absorption lines through very narrow bandwidth filters. Such observations reveal periodic intensity fluctuations as the absorption feature is Doppler-shifted in and out of the filter's bandpass.

When the entire solar disk is imaged through such filters, it is seen to consist of a complex pattern of light and dark regions, each vibrating with the five-minute rhythm. The oscillations can even be observed in integrated light — where the Sun is viewed as if it were a distant star.

The original discovery of systematic oscillations was an unexpected event. Since the overall pattern seems chaotic at first, with each small region oscillating independently of nearby regions (see the bottom of the facing page), the conventional wisdom of the time imagined random motions due to changing patterns of convection. For a decade it was not clear that the fluctuations displayed any underlying Sun-wide coherence.

Only about 15 years ago was it proposed that the whole Sun is vibrating as a resonant object. The apparently incoherent surface fluctuations are now recognized to be due to interference between a large number of different overtones, or "normal modes" of global oscillations with periods in the range 2.5 to 11 minutes. Since these vibrations are triggered continuously at many different points, the Sun has been likened to a gong being rung by wind-blown sand.

These oscillations are, in fact, seismic waves in the Sun, and their study is called helioseismology. Similar effects may also



Solar oscillations can be very complex, but are more easily understood when classified by their *l* and *m* values. These parameters represent the number of nodes (stationary points) belonging to each oscillation. A simple vibrating violin string, for example, has (a minimum of) two nodes, one at each end. The *l* parameter represents the total number of nodal planes slicing the Sun's surface. The *m* value gives the number of planes cutting perpendicular to the equator. The computer-generated images corresponding to the sketches show how various parts of the solar surface would move if the Sun were oscillating with an *l*-value of six and various values of *m*. The dark regions in the images are the nodes, while the yellow areas can be thought of as moving toward us and the green portions moving away. At left, there are no nodal planes perpendicular to the equator so *m* is zero. At center, six planes still cut the Sun, but because three are oriented vertically *m* is three. At right, the *l* value remains six, but as all the planes are vertical, *m* is also six.

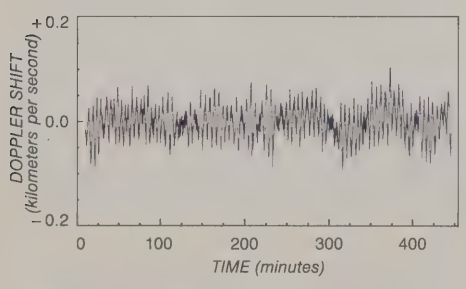
have been observed on some other stars (see the box on page 475).

The propagation of seismic waves is affected by temperature, which increases inward toward the central fusion furnace and causes the speed of sound to increase also. Thus if a sound, or acoustic wave, is excited near the surface and propagates inward, the lower portion of its wave front will be speeded up, and eventually the wave will be refracted back toward the surface. (The effect is analogous to the bending of electromagnetic waves in the Earth's ionosphere or light waves in a mirage.)

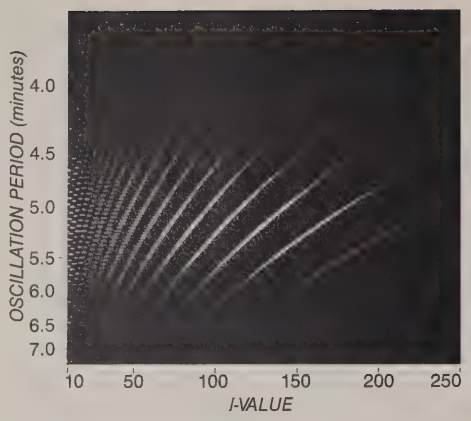
A second change in direction occurs as this refracted wave returns to the surface. There it encounters an abrupt decrease in density — the visible surface of the Sun. A sound wave cannot move efficiently across such a steep gradient, which acts like a boundary and reflects the wave back inward again (see the diagram on page 470). Trapped in this way, the wave must propagate within a spherical shell, or cavity, whose inner and outer boundaries depend on the physical characteristics of the solar interior. In fact, the wave may travel around the Sun many times, interfering with itself and establishing a standing-wave pattern that may last for days. The oscillations resulting from the bouncing wave will have a period that depends on the physical conditions within the cavity.

Because the Sun is nearly spherical, its oscillations can be described by expressions called "spherical harmonics." These mathematical functions are characterized by two special numbers, l and m, whose values describe the surface wave pattern.

For individual oscillation modes, such patterns are easy to visualize. All standing waves are characterized by fixed regions called nodes, where nothing moves (just like the ends of a vibrating violin string). In a spherically symmetric situation, like that of the Sun, the nodes lie on planes cutting through a central axis. These



The Sun simultaneously vibrates with millions of oscillation modes. The complexity of solar "five-minute" oscillations can be gauged from these observations of Doppler shifts displayed by a portion of the Sun 2 arc minutes across.



Solar physicists realized that "five-minute" oscillations (they actually have periods from 2.5 to 11 minutes) weren't random when they plotted l values for individual modes against their periods. Instead of scattering, the data points line up along regular curves, which indicate the Sun oscillates coherently. These particular results were obtained at the South Pole in 1983 by Thomas Duvall, Jr., John Harvey, and Martin Pomerantz.

planes can slice either parallel to the sphere's equator (latitudinal planes) or at right angles to it (longitudinal planes). The parameter m is simply the count of longitudinal planes, while l is the total number of nodal planes cutting parallel and perpendicular to the equator (see the diagram on page 471).

The quantity l is especially useful in talking about surface waves because it gives a quick overall idea of their scale. For example, a large l means the number of waves is large. Thus, their wavelengths must be small to fit them all in.

In principle, both l and m can be derived by observing the actual surface velocity patterns. Unfortunately, what we see on the Sun is the sum of millions of different l and m combinations. Untangling them from each other is one of the principal observing challenges facing helioseismologists today.

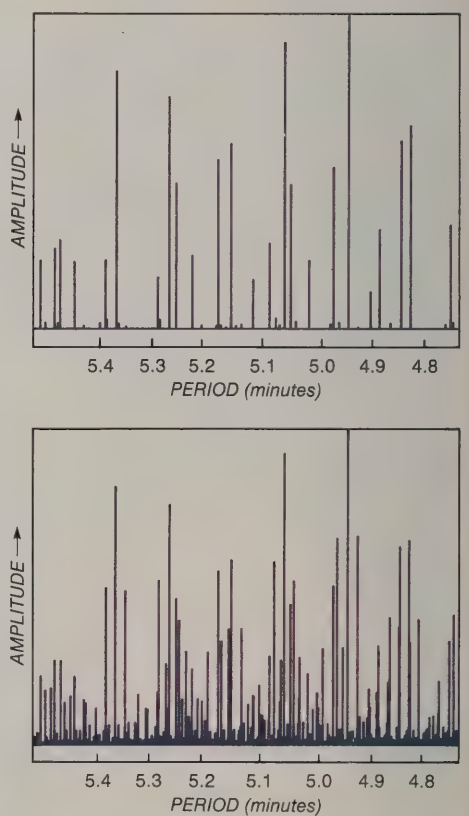
PROBING THE DEPTHS

Prior to the advent of helioseismology all of our knowledge of the solar interior (except for neutrino counts) came from measuring physical conditions at the surface. Astronomers could then use their theories of solar structure to infer the subsurface conditions giving rise to the observed luminosity, temperature, and density. Such extrapolations are, however, dependent on the model astronomers use. Thus, researchers cannot distinguish between rival theories that predict the same surface conditions.

As we have seen, solar seismic waves offer a new opportunity to probe the structure and dynamics of the Sun's interior. For example, the penetration depth of a given wave depends on its wavelength. Longer waves travel deeper into the Sun than shorter ones, so oscillations with small-l values reach to greater depths than oscillations with large l's.

The depth at which an inward-traveling wave is refracted outward is determined by the sound speed (and thus the temperature) at that point in the Sun. By careful computer analysis of the frequencies of a large number of different oscillation modes, progressively deeper layers of the Sun can be "peeled back" to reveal how the sound speed and thus the temperature vary with radial distance from the Sun's center. In this way helioseismologists expect to create accurate cross-sectional pictures of the Sun's interior just as geologists use earthquakes to study the Earth's internal structure.

To do this researchers must make precise measurements of the Doppler shifts



One of the greatest problems in identifying periodic signals is to distinguish between real and spurious ones. When studying solar oscillations, false signals introduced by gaps in the data due to weather and night are a major problem. The upper graph shows a computer simulation of five-minute oscillations. The lower curve shows how the same data would look when contaminated by diurnal and weather effects. Courtesy Frank Hill and Gordon Newkirk.

of individually resolved regions on the solar surface and determine both the wavelengths and frequencies of the various waves. For the "five-minute" oscillations, values of l from 0 to over 2,000 have been observed. These correspond to pulsations with periods ranging from 2.5 to 11 minutes and possibly longer (see the diagram on top of facing page).

RESULTS SO FAR

Helioseismologists are pursuing their studies in a variety of ways. Low-l modes are studied by looking at integrated sunlight from one or more observing sites. Others are monitoring images of the solar disk to disentangle various high-l modes.

This work has already led to important discoveries. For example, observed oscillation frequencies seem to be consistent with an initial solar helium abundance near 25 percent. This is the primordial value predicted by cosmologists and appears to exclude the "helium-poor" explanation of the solar neutrino shortage.

Other observations strongly suggest that the Sun's convective zone extends deeper into the interior than was expected. If correct, this means that convection is a more efficient heat transport mechanism than previously thought. It also raises the possibility that convection currents can move material from the outer layers into high-temperature regions far below. If so, easily fused elements such as lithium might be consumed, thus affecting their observed abundance (see the January issue, page 28).

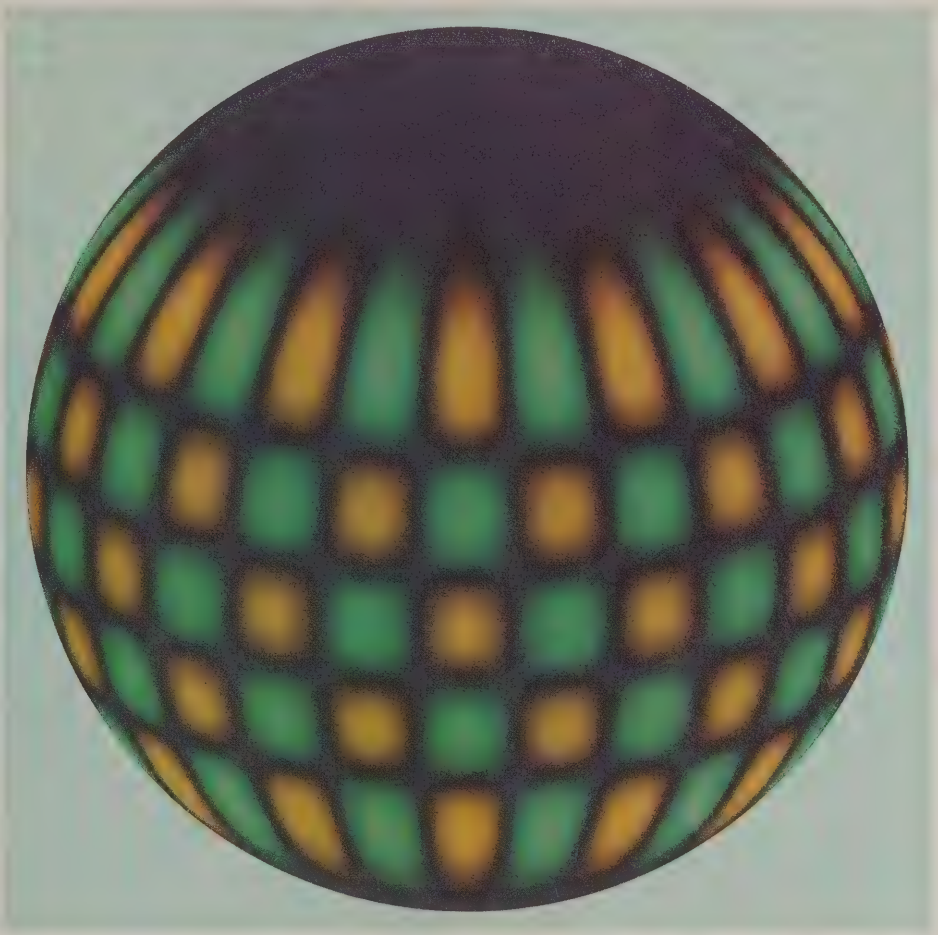
Yet another consequence concerns a classic test of Einstein's general theory of relativity. The point at which Mercury is closest to the Sun (its perihelion) is not fixed in space but rotates, or precesses, at a rate slightly greater than that predicted by Newtonian theory. This excess precession agrees almost exactly with the amount predicted by relativity, but only if the Sun is spherically symmetric throughout.

While the Sun's surface appears spherical to a high degree, the configuration of the solar interior may be different. It is possible that the Sun's core is spinning much faster than the surface and therefore might be distended along the equator. In fact, there is a theory that the outer layers of the Sun have slowed down significantly over the ages due to angular momentum losses via the solar wind. In other words, the outflow of matter magnetically tied to the Sun's surface has the same braking effect on solar rotation as spinning ice skaters experience when they extend their arms.

Oscillation measurements, however, suggest that as we go deeper into the Sun the rotation rate actually slows very slightly, the opposite of what would be expected from magnetic braking. Thus, it would appear that helioseismology has helped general relativity successfully withstand another onslaught.

A WORLDWIDE EFFORT

While studies like this continue to be productive, the frequencies of individual oscillations must be measured much more accurately if we are to advance further.



A simulation of one of the millions of solar-oscillation modes. Places that are stationary — nodal planes — appear as dark lines, while regions approaching us are yellow and those receding are green. The number of nodal planes — the l value — is 18. Of these, 14 are arranged perpendicular to the solar equator; therefore the m value is 14.

GONG observing sites will be located at approximately 60° intervals around the globe. Ten sites (plus Tucson, Arizona) are currently being tested. The final six will be chosen in 1990.

To obtain the necessary data for future studies, measurements must be made about once a minute for at least two or three years! Unfortunately, this introduces another complication; night tends to periodically interrupt solar observations!

The day-night cycle may not seem to be a major problem, but it is. Such interruptions contaminate the data with an artificial period of one day. This signal, plus its harmonics (rational fractions of 24 hours), are superimposed on every solar signal to produce a complex mix of real and false periodicities. To avoid this confusion, a virtually unbroken set of observations is essential (see page 472).

Apart from observing at the Earth's poles (*S&T:* December, 1982, page 520), continuous monitoring can be obtained in two different ways: by establishing a network of observing sites around the world, or by launching a single observatory into space. At the present time the Earth-based alternative is the less expensive approach and certainly the one that promises the earliest results.

The idea of continuously monitoring solar oscillations with a worldwide system of telescopes was spurred by the success of pioneering observing networks such as the one organized by the University of Birmingham in England. While the GONG concept sprang up within the solar physics community over a number of years, its exact origins seem lost in the sands of time.

The project first took on a coherent form at a 1984 meeting hosted by the NSO. The consensus of the conference participants was that a world-spanning observing network was feasible. It was also decided that NSO was the logical focus of such a project, since its mission is to provide first-rate observing facilities for the entire solar physics community.

GONG would have to meet many stringent requirements. It would need very sophisticated instruments, though with plenty of light available their telescope apertures could be tiny by astronomical standards. Ideally, the whole system would operate automatically. In practice, however, the observing stations would require occasional servicing and collection of data tapes. Thus, logistical problems could best be handled if GONG instruments were located at existing astronomical sites.

Provided that interruptions are random, observing the Sun about 95 percent of the time is sufficient to gather the data needed to unscramble the oscillations. This means that a minimum of three stations separated by 120° of longitude are required so that the Sun is always well above the horizon of at least one. Of course, this scenario assumes that the weather is always perfect and the equipment always works! Computer simulations that allowed for equipment failures and included real weather data indicated that a minimum of six sites, spaced roughly equally in longitude, would actually be required.

The scientific questions GONG would answer have such a fundamental impact on all of astrophysics that the proposal gained very broad support in both the night-time and solar astronomy communities. GONG was seen as a two-part effort. NSO would develop and operate both the network and a central data-analysis facility. On the other hand, the individual researchers would form a dozen or so science teams to handle data analysis. The project would require a total of nine years and some $15 million to obtain three years of actual observations.

In late 1985 the National Science Foundation provided interim funding to get serious planning for the project underway. GONG was officially recognized and funded in late 1986. In that short time membership in the group grew to over 100 scientists, and nearly as many technical people, representing more than 40 research institutions worldwide. The NSO effort alone will eventually involve a staff of more than 25.

GONG is now proceeding along four parallel fronts: a survey of the actual observing conditions at various sites; the

Site-testing telescopes like this one at Cerro Tololo Inter-American Observatory in Chile are currently operating at 11 sites around the world. The six best locations will become hosts of the GONG network in the early 1990's. This *Sky & Telescope* photograph was taken by Dennis di Cicco in October, 1986.

development of a highly automated, extraordinarily sensitive instrument to measure the velocity of thousands of points across the solar disk; the data reduction and analysis system to process the observations; and the formation of the science teams.

The requirement for six observatories equally spaced around the globe does not allow for an arbitrary set of choices. One major problem is the shortage of sites in the Pacific Ocean, the most reasonable option there being Hawaii. This selection dictates the nominal longitudes for all the other stations. Happily, seeing is not a critical issue, since the resolution of GONG's detectors is lower than the typical blurring effect of atmospheric motions. On the other hand, persistent good weather is a high priority.

Ten different sites at the six desired longitudes are currently being tested with small automatic trackers like the one shown on the facing page. These devices record the brightness of the Sun all day long. In addition to a reference instrument in Tucson, Arizona, sites under consideration include: Mauna Kea and Haleakala, Hawaii; Mount Wilson and Big Bear, California; Yuma, Arizona; Cerro Tololo and Las Campanas, Chile; Izana, Canary Islands; Udaipur, India; and Learmonth, Western Australia.

Preliminary data from the survey instruments suggest that GONG should be able to monitor the Sun 96 percent of the time. More important, the observations are virtually free from contamination by the deadly 24-hour periodicity, as shown by the illustration on page 472. Site surveying will continue for about three years to establish the long-term performance of different combinations of stations (see the map on page 473).

DATA ACQUISITION

The five-minute oscillation is a subtle effect. Individual modes may exhibit velocities of less than 20 cm per second, while the sum of all the modes is only a few hundred meters per second. The ultimate intention is to have GONG's measurements limited only by the Sun's "random" surface motions. This means developing six stable instruments capable of making velocity measurements of individual points on the Sun with a precision significantly better than one meter per second.

The basic observing technique to be used involves monitoring a single absorption line in the solar spectrum and determining its precise Doppler-shifted wavelength. The instrument chosen for this task is called a Fourier tachometer (described in the box on the next page). By simultaneously processing light from all parts of the solar disk, it produces line-of-sight velocities at over 65,000 points on the Sun's surface. Every minute or so a computer stores this "velocity image" on magnetic tape together with a conventional "intensity image."

The entire instrument will reside in an environmentally controlled building that houses the "light-feed" (it's so small we can hardly call it a telescope), Fourier tachometer, control and acquisition computers, and data recording equipment. The light-feed is fully automated and each day will turn itself on, locate, and track the Sun.

Even at first glance, it is clear that analyzing the GONG observations presents two challenges. First, the volume of data will be monumental. Second, extracting results is a long and complex computing task. Each station will produce at least 200 megabytes of data every day. The

The Birth of Stellar Seismology

The Sun is not the only star vibrating in a complex manner. Astronomers have now observed similar behavior in a number of other stars. Just as the young science of helioseismology is providing new information on the Sun's interior, so the even younger field of stellar seismology is revealing new facets of star structure. A recent example of this concerns a mystery surrounding the age of our neighbor Alpha Centauri A.

Solar-like oscillations should not be confused with the pulsations exhibited by stars like Cepheids and RR Lyrae variables. The Sun is vibrating in tens of millions of different modes simultaneously. Most conventional variable stars show only one or two different oscillations.

Stellar seismology dates back to the early 1980's. In 1982 Donald Kurtz (University of Cape Town, South Africa) discovered fluctuations in the light output of the chemically peculiar *A*p stars, which he interpreted as evidence of powerful oscillations. Detecting the much weaker signals of variability in stars like our Sun came a few years later. Then, in 1984, French astronomers announced that they had observed an analogue of the Sun's so-called five-minute oscillation in its near-twin, Alpha Centauri A (*S&T:* December, 1984, page 509). At almost the same time, a U. S. group reported similar findings about the *K* star Epsilon Eridani.

To follow up their earlier work on Alpha Centauri A, the Nice-based team of Bernard Gelly, Gérard Grec, and Eric Fossat used the European Southern Observatory's 3.6-meter telescope. Combining their new data with the old revealed some surprises.

Alpha Centauri A's five-minute oscillation actually has periods ranging from 3.5 to 8.5 minutes, in good agreement with theoretical predictions. However, the oscillation's strength was 5 to 10 times larger than expected. Even more worrisome was the value derived for this star's radius, only 93 percent of the Sun's. This value differs substantially from the well-established 1.23 solar radii calculated from spectroscopic data.

Gelly and colleagues regard this finding as "really puzzling." As stars grow old, they expand. So one possible explanation is that astronomers have overestimated Alpha Centauri A's age. But, even if it has a "zero age" (that is, it has just started burning hydrogen), "we have to assume a mass of 1.0 [instead of the standard 1.09 Suns] to fit the theory." They also suggest that the star's chemical composition might be slightly different from the Sun's. If this is so, then the star's properties cannot easily be compared with those of the Sun.

While our closest stellar neighbor has caused some problems, Procyon has done just the opposite. Gelly and coworkers observed Alpha Canis Minoris with the 3.6-meter Canada-France-Hawaii Telescope in February, 1984. They found 5-minute oscillations with periods ranging from 10 to 25 minutes, just as they expected. Happily, Procyon's radius turns out to be in agreement with theory. Moreover, the actual value obtained, 1.87 Suns, suggests that Procyon is near the end of its main-sequence life, again consistent with calculations.

The Nice team also revealed how Procyon's oscillations are excited. For the Sun this is an extremely difficult question, because the predictions of rival models can hardly be distinguished. This is not the case for Procyon. The stellar seismology strongly favors the random excitation of oscillations by turbulent eddies in Procyon's convection zone.

So far, the French team's work is unconfirmed. As one U. S. observer put it, "Everything in this field is controversial until it's boring."

DAVID H. SMITH

whole network will generate a gigabyte a day, seven days a week, for three years. The total amount of data to be analyzed will exceed one terabyte!

To reduce the data, every image from each station must be adjusted, pixel by pixel, for a variety of instrumental, photometric, and geometric effects. Furthermore, Doppler shifts caused by the motion of the Earth about the Sun must be removed. Since as many as three GONG stations will be observing simultaneously for several hours, their data must be merged into a single stream by automatically selecting the best frames available at each moment.

Merging the data is, in itself, no simple task. To do it properly a pixel from one station must represent the same area of solar surface as the corresponding pixels from every other station. But, due to differences in optical magnification, tracking, changing zenith angle, and a host of other effects, the pixels will never correspond exactly. Thus all distortions must be measured and used to re-map every pixel back onto a "standard image frame."

Once these housekeeping tasks are complete, several more computer-intensive operations will be undertaken to derive, for example, the spectrum of oscillations. Finally, the raw and reduced data, plus several intermediate stages must be archived in computer-readable form using a combination of optical disks and magnetic tapes.

PROJECT TIMETABLE

The development of the field instrument is underway and a prototype system will be ready next spring. Once it has been tested, construction of the six final instruments will begin later in the year. These units will be installed at the six selected observing sites in 1990, and the full network should be in operation early in 1991. The data reduction and analysis components of GONG are being developed concurrently.

The GONG project is slated to gather data for a minimum of three years, with full-scale data analysis continuing for at least one additional year. If the results indicate a need, data-gathering may continue over a longer fraction of the solar cycle. In any case, beginning in the early 1990's, we can look forward to some truly exciting developments in our understanding of how our star works.

John Harvey is the GONG instrument scientist. James Kennedy is the GONG project manager. John Leibacher is the GONG project scientist. All three are helioseismologists based in Tucson, Arizona.

The Fourier Tachometer

The heart of the Fourier tachometer is a Michelson interferometer made from a polarizing beamsplitter and an assortment of polarizers and mirrors. The interferometer splits an incoming light ray into two parts, which follow separate paths or "arms." At the end of each arm a mirror reflects the light back into the beamsplitter where the two beams recombine and interfere with each other.

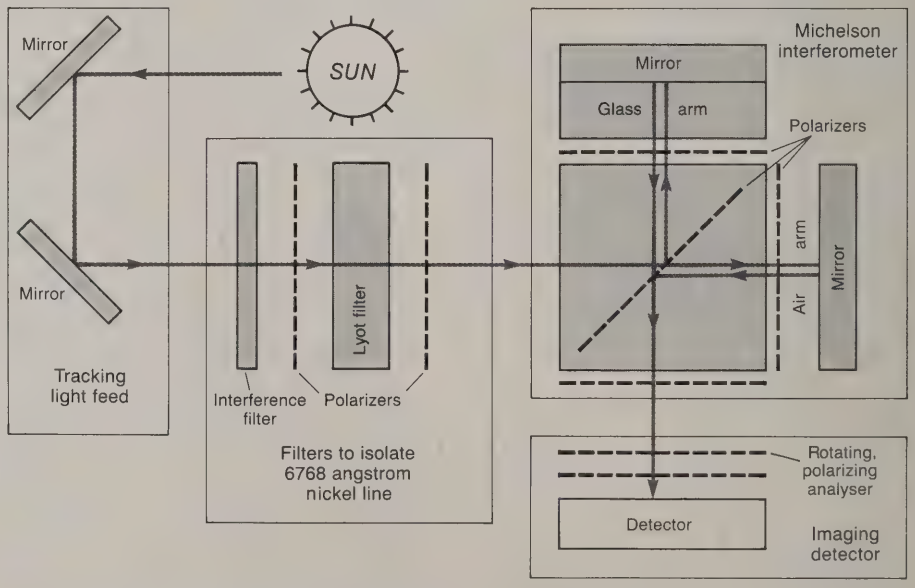
If the two rays are in phase (that is, the peaks and troughs of the light waves coincide exactly), the resulting image will be bright. If they combine out of phase (that is, with peaks aligning with troughs), the resulting image will be dark. More commonly the rays will be neither exactly in or out of step with each other. In practice, the actual brightness of the image formed is a measure of the phase difference between the two beams.

The ability of the interferometer to detect slight phase differences is crucial to how the Fourier tachometer measures small Doppler shifts on the solar surface. Because one arm of the interferometer is glass and the other air (see the diagram below), a very slight variation in the wavelength of the light entering the interferometer changes the relative phase of the two rays as they recombine in the beamsplitter.

The glass arm is 30,000 wavelengths longer than the air arm. This means that any phase shift is magnified over this large number of extra wavelengths and results in a more obvious change in the brightness of the output beam. In the GONG instrument a Doppler shift of 5 kilometers per second (approximately a 0.1 angstrom wavelength change) is sufficient to alter the output image from bright to dark.

For GONG, sunlight from a 6-cm telescope objective passes through a 5-angstrom interference filter and then a 1-angstrom Lyot filter to isolate the neutral nickel absorption line at 6768 angstroms. Because of the optical properties of the beamsplitter and several polarizers in the system, the tachometer's output is a linear wave whose plane of polarization is proportional to the phase shift. The polarization angle determines the intensity of the light as it passes through final fixed and rotating polarizers.

A key feature of the design is that the interferometer's field of view is large enough so that light from all points on the solar disk is processed in the same way and at the same time. By focusing the output image on an electronic detector, the light falling on each of 65,536 (256-by-256) pixels is modulated (by the rotating polarizer) with a phase proportional to the line-of-sight velocity of that part of the solar disk. Measuring Doppler shifts then becomes a matter of measuring the phase of this signal for each pixel.



The principal components of the Fourier tachometer, the instrument at the heart of the GONG network, are shown here schematically. Sunlight from a small tracking mirror passes through various filters, a Michelson interferometer, and a polarizing analyzer before finally being detected by a solid-state imager.

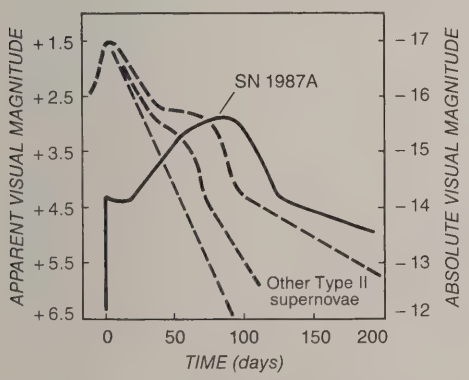
Supernova 1987A after 200 Days

NOW THAT over 200 days have passed since Supernova 1987A appeared, astronomers can begin to look at its long-term behavior. Although its early brightness variations were unique, the new star appears to have settled down to a slow, steady fading. In late September it shone at magnitude 5.1. Since about June 25th SN 1987A has been dimming by some 0.01 magnitude per day in visible light. At this rate the astronomical event of the century will become invisible to the unaided eye around Christmas, though it should remain within reach of small telescopes for many months thereafter.

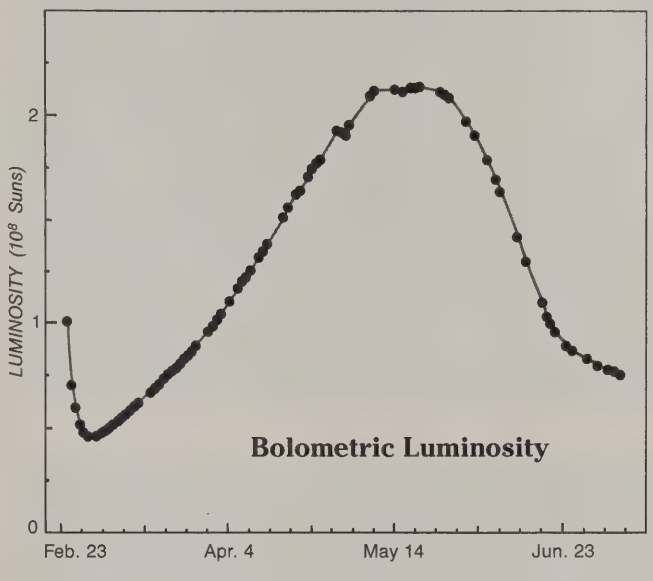
The current rate of decline is similar to that experienced by some other Type II supernovae and may be controlled by the decay of radioactive nuclei produced early in the explosion. A pulsar (rapidly rotating neutron star) at the center of the supernova's still-opaque debris cloud may also be injecting energy into the system, but so far there is no evidence for such an object. Of course, even if a pulsar *is* present, it is a matter of chance whether we will ever see its periodic signal. A pulsar emits beamed radiation much like a lighthouse does, and if the beam fails to sweep over us we will not be able to detect it.

The Japanese Ginga satellite may have made the first X-ray detection of SN 1987A on August 15th. On that date there was a significant increase in X-ray radiation from the vicinity of the supernova, compared to previous observations. The excess was confirmed in early September. As yet there is still no evidence of gamma rays from the explosion, and the late-June radio detection reported on page 258 of the September issue has not been confirmed. The supernova has remained "radio quiet" since its modest initial burst faded away.

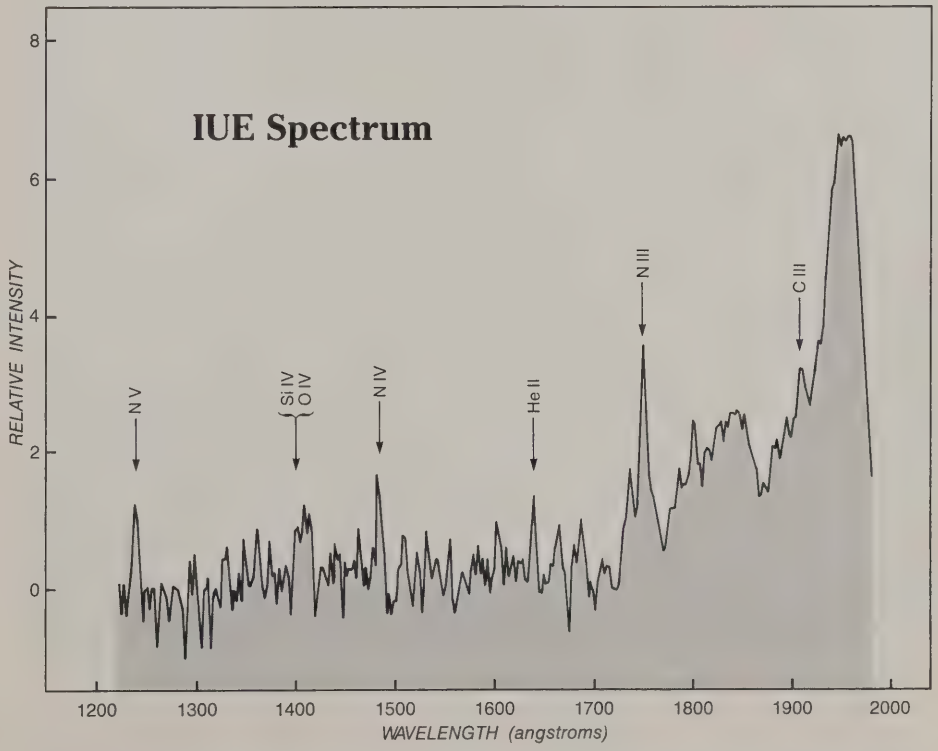
Nevertheless, the supernova's spectrum keeps on changing. Narrow emission lines first appeared in the ultraviolet in early June. Since then these features have grown steadily stronger. As the spectrum below shows, the atoms producing the lines have lost a number of electrons (that is, the "excitation" is high), and nitrogen features are particularly strong. According



Supernova 1987A has now settled down to a slow, steady fading since late June, when the trend of its visual light curve changed noticeably. The new star's behavior is contrasted with those of three other Type II's, shown as they would have appeared in the Large Magellanic Cloud if their peak luminosities were the same. The time scale has been adjusted so that the core collapse for Supernova 1987A corresponds to the peak luminosity of the other examples.



The total (bolometric) energy output of SN 1987A has varied in a way that is similar, but not identical, to the visual light curve. This graph was calculated from data obtained in Cape Town and at the Sutherland field station of the South African Astronomical Observatory. Original illustration courtesy Robin M. Catchpole and colleagues.



The ultraviolet spectrum of SN 1987A as recorded by the International Ultraviolet Explorer satellite. Note the narrow emission lines from ionized hot gases. Data from several days have been averaged, and the spectrum from March — before the emission appeared — has been subtracted to remove the contributions of two companion stars. Illustration courtesy Robert P. Kirshner.

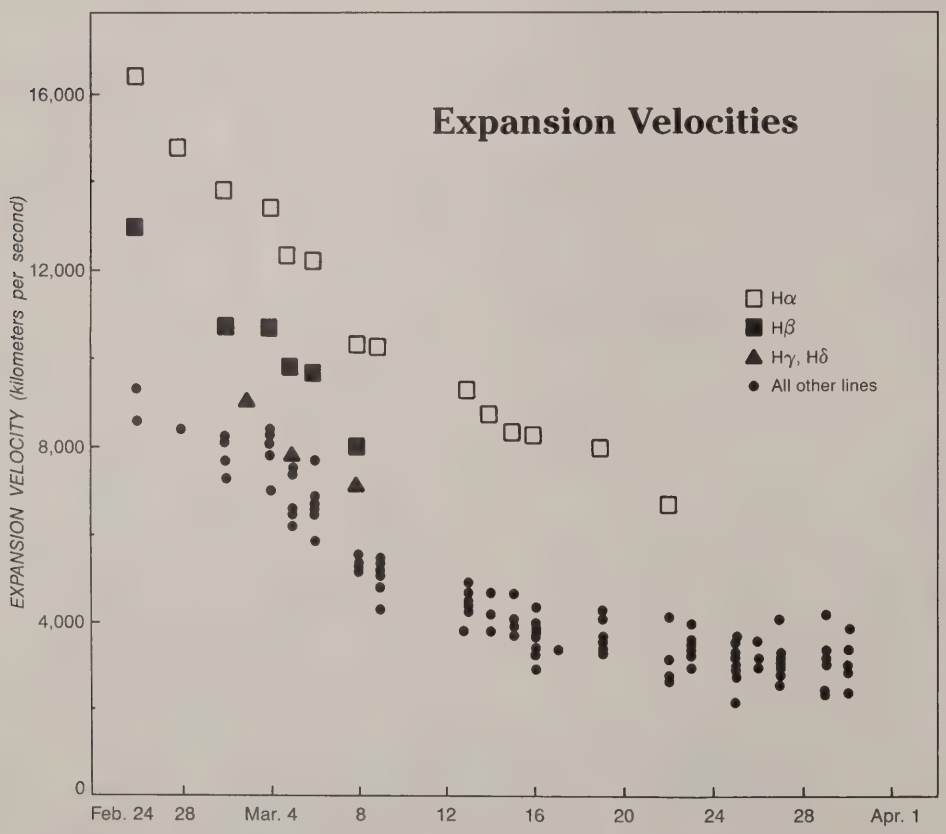
to Robert P. Kirshner (Harvard-Smithsonian Center for Astrophysics) these lines probably arise from circumstellar material that was ionized by the initial flash of ultraviolet light from the blast.

If Kirshner is right, then there is the possibility of a spectacular interaction between the outrushing blast wave and the cloud now producing the narrow lines. It took the ultraviolet radiation some three months to reach the circumstellar gas, and since the fastest material in the debris cloud is traveling a little slower than one-tenth the speed of light, the fireworks might start some 30 months after the explosion, in the summer of 1990.

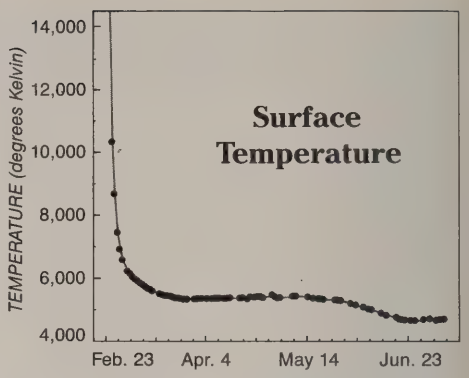
OUT, DAMNED SPOT!

What of the Mystery Spot accompanying the supernova (see the September issue, page 259)? At present, nobody knows for certain what it is, or what it was, or even if it ever was! As related in the October issue, page 349, the story took a new twist when the spot was *not* detected by scientists from the Center for Astrophysics in observations made from May 30th through June 2nd. This failure implies that the spot, if it actually exists, was at least 4 magnitudes fainter than the supernova at that time. Infrared data from the European Southern Observatory (ESO) also showed nothing down to 10 percent of the supernova's brightness on May 8th and 9th. Additional ESO observations between June 16th and 23rd revealed nothing.

Observations during the late spring and summer were hampered because the Large Magellanic Cloud was below the celestial pole during the night. It's anybody's guess whether the Mystery Spot will be found again now that observing conditions have improved and the supernova has faded. Such a spot could not have been seen had the explosion occurred in a more distant galaxy, and since there have been no nearby visible supernovae since the telescope was invented, astronomers have little to go on in their attempts to explain what might have been the cause of the earlier sightings.



Expansion velocities for SN 1987A showed a dramatic decrease in the first few weeks after outburst. The blast was not slowing down, but instead we could see spectral lines from lower-lying, slower-moving material that became visible as the outer layers of the debris cloud thinned and became transparent. Similarly, different lines show different velocities at the same time because the features arise at different depths in the star's outer layers. The speeds shown were determined from the wavelengths of the blueshifted absorption-line centers, which are relatively easy to measure. The data plotted here were derived from spectra taken by B. N. Ashoka and colleagues at the Vainu Bappu Observatory in India. Adapted from the *Journal of Astrophysics and Astronomy*.

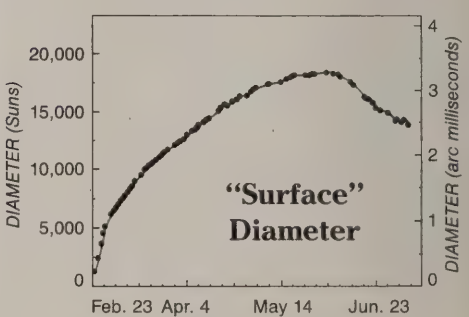


The temperature of the supernova's visible surface plummeted in the first few days after the explosion. However, after a few weeks the temperature leveled off at a very low value as new material from below kept coming into view. Diagram courtesy R. Catchpole and co-workers.

IN THE NEIGHBORHOOD

High-dispersion spectra from the Anglo-Australian Observatory revealed a sharp absorption feature due to [Fe X] (iron stripped of nine electrons). This is the first detection of this so-called forbidden line *in absorption,* though it is a strong and well-known *emission* feature in our Sun's corona (the "red line" at a wavelength of 6375 angstroms).

The presence of this iron absorption suggests that SN 1987A lies behind a region filled with low-density "coronal" gas at a temperature above 1 million degrees Kelvin. This hot material may be the result of earlier supernovae, for this neighborhood of the Large Magellanic Cloud has recently been the scene of intense star-forming activity and is strewn with young, massive stars and their parent nebulae. The total mass of ionized gas



The visible surface, or photosphere, of the supernova first swelled and then began to contract. While debris from the blast is still expanding freely into space, the gas is thinning and we are now looking deeper and deeper into the expanding cloud as time passes. Eventually the photosphere should retreat far enough to reveal what, if anything, remains at the site of the explosion. Adapted from a diagram by R. Catchpole and coauthors.

involved could exceed that of 10 million Suns, which is comparable to the amount of neutral hydrogen in the nearby gigantic 30 Doradus nebula.

ON OTHER FRONTS

SN 1987A might have been discovered by its neutrino emission several hours before it reached naked-eye visibility had scientists been looking for it. Could evidence for other, visually obscured, supernovae in the Milky Way lie unrecognized in data from neutrino detectors? Now that they know what to look for, scientists are searching their old files but so far have drawn a blank. Similarly, there is no evidence for a nearby supernova *since* SN 1987A.

Happily, the neutrino detectors, which faced uncertain financial futures not too long ago, have gained new leases on life this year, and "missed" galactic explosions such as Cassiopeia A should be a thing of the past.

Soon after the supernova's discovery there was a brief flurry of interest in the possible detection of gravity waves from the event. Unfortunately, all the world's cryogenically cooled gravity-wave detectors were off the air at the time, and only a few of the less sensitive room-temperature variety were operating (see the October issue, page 364). Several positive results were tentatively announced, but they now seem spurious. For one thing, an enormous mass, say some 1,000 Suns, would have had to collapse to produce the reported signal. Such an event seems ruled out for a variety of reasons. For one thing, where could such a massive and necessarily luminous host star have hidden until it exploded? For another, a spherical collapse, which is more or less what happened according to the neutrino results, does not produce gravity waves. They require an *asymmetric* collapse.

Did the supernova arise in a close binary system? There is no definite evidence that it did, and no pressing need for such a complication. Still, some scientists feel that a double star might account for the observations better than a solitary one. If so, some remnant of the companion could still be present and might eventually show itself. For now there is still a lot of opaque material between us and whatever lies at the center of the exploding supernova. Yet the intervening cloud is expanding and thinning out, and every second there is less and less matter blocking our view. The coming months and years should reveal the answers to many questions about what lurks at the heart of SN 1987A.

RONALD A. SCHORN

Akira Fujii captured these spectra of Supernova 1987A and its surroundings with a 35-mm camera in Australia. Labels identify selected stars and give their spectral types. Fujii used a 23° objective prism and Fujichrome 400 film. He caught the new star on April 27th, when it shone at magnitude 3.0. *Top:* A wide area of the southern sky around the supernova shows in this 10-minute exposure made with a 50-mm, f/2 lens. The overexposed spectrum of the luminous supergiant Canopus is by far the brightest feature in the scene. *Bottom:* The immediate neighborhood of SN 1987A is revealed in a 15-minute exposure taken with an f/4 lens having a focal length of 200 millimeters.

Amateurs Triumph in Paris

ON JUNE 20th over 300 professional and amateur astronomers from 27 countries converged on Paris for one of the most significant events in the history of amateur astronomy. Strictly speaking, they came to celebrate the 100th anniversary of the Société Astronomique de France (SAF). But, more important, they came to acknowledge the research and educational contributions that amateurs are making to astronomy.

An invasion of armies can be resisted, but not an idea whose time has come.
— Victor Hugo

The International Astronomical Union — astronomy's venerable professional organization — cosponsored the affair with five amateur societies from four countries. "IAU Colloquium 98" was the first under that organization's aegis to have a purely amateur theme. To many, it signaled a dramatic reversal in the rift that had been widening between amateur and professional astronomy.

The IAU has wanted to include an amateur body in its organization for decades. In 1967 it helped organize the International Union of Amateur Astronomers, but that failed miserably (see the box on page 482). SAF president Paul Simon saw the centennial as a good opportunity to renew the relationship.

The SAF possesses a long history of amateurs and professionals working closely together. Camille Flammarion, who founded the SAF in 1887, was a professional astronomer turned amateur. He left the profession to pursue his amateur interests and to popularize astronomy. In time he published 10 books on the sky and started the review, *l'Astronomie*.

In June the Société Astronomique de France (SAF) and the International Astronomical Union (IAU) held a five-day colloquium to recognize contributions of amateurs to astronomy. The meeting was held near the Arc de Triomphe, a fitting symbol for the occasion. Photograph by the author.

Flammarion eventually became so famous for popularizing astronomy that the professionals virtually *had* to work with him. Yet the director of Paris Observatory was against founding SAF. He wrote Flammarion, "You will not find anybody to put one franc into amateur astronomy." Despite his opposition, the SAF gradually grew, and half a century ago virtually all professional astronomers in France were members. But that has changed, Simon says. Today, the SAF's membership of 5,000 includes only about 100 professionals. And of those, only a few have time to work with amateurs.

Colloquium 98 addressed that problem. The concept of an amateur-professional colloquium attracted the support of 11 IAU members from six countries, who formed a scientific committee to help Simon and SAF members organize the event. Then, *voilà!* Paris (in its tradition) became the scene of an intense courtship. Each morning during the five-day event, scores of amateurs and professionals rendezvoused at the Arc de Triomphe, strolled amid the glass and gold of the Champs Elysées, then splintered into smaller groups at the nearby Centre Chaillot-Galliera.

The meeting's 122 talks covered the contributions of amateurs to astronomy throughout history, to astronomical observations, and to the popularization of astronomy. Springer-Verlag will soon publish abstracts of the presentations in two editions — one in French, the other in English.

THE WAY OF THE FRENCH

A powerful message on professional-amateur cooperation in France was delivered by Christian Buil of Toulouse. "Since the spring of 1983," he reported, "the 60-cm telescope of Pic du Midi Observatory [T60] has been at the disposal of amateur astronomers. Today, about *500* amateurs can work with that instrument! The friendly surroundings and the collaboration with professional astronomers contribute to good results."

This is much more than a casual dalliance. In September, 1985, the "Association T60" was created to enlarge the pool of potential users, establish a data bank, and assist amateurs with their projects. For example, Jean-Claude Merlin of Le Creusot has used the T60 to record the near-nuclear activity of comets. His work has appeared in French journals and the *International Comet Quarterly*.

From 1981 to 1986 Merlin, together with D. Fayard of Le Creusot and Edmond Gérard of Meudon Observatory, observed almost every known outburst of the periodic comet Schwassmann-Wachmann 1 with a variety of telescopes and instruments, including the T60. Early detection of these flares has provided astronomers with a rare chance to study an active comet far from the Sun.

Of course, Merlin has his own thoughts on what the outbursts mean. The clouds of ejected matter seem to be optically thin. He believes that successive eruptions generate the expanding halos detected visually and photographically. The halos have spiral structure, which Merlin imagines to be a consequence of a 5-day rotation period. The great bursts of energy needed to drive the dust away also suggest to him that the comet is chemically young.

Patrick Martinez of Toulouse proposes that amateurs use the T60 to assist professionals in the search for the return of periodic comets. Early recoveries, he notes, help astronomers refine comet orbits, and a magnitude estimate gives information on nuclear activity. He points out that comets are rarely recovered by amateurs — generally, professionals find them

near opposition between magnitude 18 and 20.

The T60, however, is well suited for comet recovery, especially when used to expose hypersensitized Kodak 2415 film or illuminate a CCD detector (with the latter, Buil has reached 20th magnitude). Tsutomu Seki of Japan is the one amateur who has done exceptionally well in recovering comets, and he uses a 60-cm reflector.

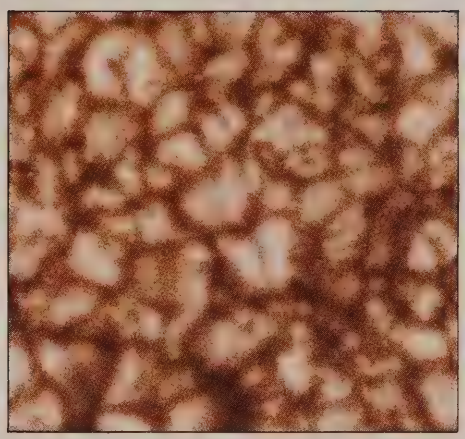
Jean Bourgeois of Conneux, Belgium, uses the 1-meter reflector at Pic du Midi for 30 percent of its observing time. He has also occasionally acquired time on a 1-meter telescope in the Canary Islands. Bourgeois now plans to establish an observing bank that will offer telescope time to amateurs or allow them to assist professionals in their research.

Strasbourg Observatory has long held its doors open to French amateurs. Roger Hellot of the Alsace Group of the SAF (SAFGA) described the origin of this enduring collaboration. When André Danjon became director of Strasbourg in 1931, he immediately formed the Alsace amateur group, gave its members access to the observatory's 20-inch refractor, and opened a channel for dialogue between the amateurs and his staff. In doing so, he gave these provincial amateurs the same advantages as those in Paris who were closer to the official headquarters.

"Today the SAFGA is as active as ever at Strasbourg Observatory," acknowledges Hellot. "The 20-inch refractor is at the disposal of amateurs for photographing the planets and observing occultations by minor planets. We hold a monthly meeting that includes a lecture by a professional astronomer, and this provides us with a framework to work with." And there is give as well as take: in 1980 three young members of SAFGA refurbished Strasbourg's 6-inch refractor.

Richard Müller and five associates have conducted two amateur-professional studies of the Sun with the 50-cm solar telescope at Pic du Midi. One explored the properties of solar granules around magnetic-field tubes. The group found that, statistically, these granules appear more numerous, smaller, and more elongated than other granules, and that for the first two minutes of life they have a strong radial orientation to the magnetic-field tube. The other program looked at how these granules rotate during their brief lives. Theoretically, they should make a complete 360° turn. But initial observations showed that only "exploding" granules — about half of all granules present — showed any evidence of intrinsic rotation.

Under the direction of the SAF's solar commission, amateurs also assist in two studies of the Sun under way at Meudon Observatory. In a white-light study of sunspot motion, an observer records positions of sunspots as often as possible, then compiles the data with the help of a professional astronomer. As explained by Jean-Marie Malherbe of Meudon, the project has several goals: (1) to determine the apparent displacements of the main spots in longitude and latitude; (2) to monitor variations within the solar cycle; and (3) to see if the spots' movement across the Sun deviates when they interact.



The granular texture of the Sun is apparent in this high-resolution close-up taken with the 50-cm solar telescope atop Pic du Midi. Richard Müller and a team of amateur and professional astronomers are studying how individual granules orient themselves around magnetic-field tubes. The diameters of the smallest bright features are about 0.3 second of arc, or roughly 200 km.

The second program will begin next year. Its participants are to study the appearance of prominences along the Sun's limb in hydrogen-alpha light. Observers will watch for eruptions, measure their velocities, and interpret them. "The variety of techniques and the geographical distribution of amateurs are going to make this program a success," Malherbe predicts.

Such striking examples of amateur-professional involvement were the envy of many foreign amateurs at the Paris gathering.

WORLDWIDE ACTIVITIES

From neighboring West Germany came Klaus Reinsch of Berlin, who described *Sonne,* a decade-old journal dedicated to the "classical" study of the Sun. The most successful of its many ventures is a worldwide sunspot-observing network of more than 130 observers. Each year the

More than 9,400 feet high in the French Pyrenees, Pic du Midi Observatory is the site of much professional-amateur collaboration, where about 500 amateur astronomers have access to a 60-cm reflector. Photograph courtesy Pic du Midi Observatory.

group receives approximately 17,000 individual observations, from which it determines the daily Wolf sunspot number.

Once launched next year, the European Space Agency's Hipparcos satellite will begin to measure the positions, motions, and parallaxes of 100,000 stars with an accuracy of 0.002 arc second. Yet its list of targets is riddled with multiple-star systems having incorrect positions, questionable catalogue references, unclear component designations, and other ambiguities. Groups of amateurs in France, Belgium, and Germany have undertaken the task of observing and identifying these problem stars, so that Hipparcos' catalogue can be updated before the spacecraft flies.

Annie-Chantal Levasseur-Regourd of Paris University wants to spur on amateurs globally in another space effort. She asks that they monitor comets Temple 2 and Grigg-Skjellerup in preparation for NASA's proposed Comet Rendezvous Asteroid Flyby (CRAF) mission. "You have work to do," she urges.

According to Stephen Edberg, International Halley Watch (IHW) coordinator of amateur observations, the IHW does not intend to archive such observations as they did for Comets Halley and Giacobini-Zinner. "However," says Edberg, "we are encouraging amateurs first to observe these comets, and then to publish results in the normal manner. 'Normal' in this case is through the *International Comet Quarterly* and other journals."

One of the most successful amateur organizations is the American Association of Variable Star Observers (AAVSO). As of July, 1986, the AAVSO had 1,200 members worldwide and had amassed over 5,650,000 observations. These magnitude estimates have helped professional astronomers address a number of problems concerning the pulsation, instability, and time variation of stars.

AAVSO director Janet Mattei notes that the number of contributions by its members has risen sharply to keep pace with demands by professionals. She adds that since 1970 visual data have gained importance by supporting the increased X-ray and radio-wavelength observations made by professionals.

"It's very exciting in this age of high technology to know that professional astronomers depend on amateurs in planning their observing," Mattei beams. "The dedication and enthusiasm of our observers, and the high quality of our variable star data, have made this unique collaboration possible." To illustrate the importance of this communion, Mattei cites a letter by Michael Bode of the University of Manchester in England:

> The AAVSO has several times recently provided me with data on the visual behavior of variable stars being observed at other wavelengths by satellites and ground-based facilities. In one classic case, we obtained simultaneous observations of the dwarf nova SU Ursae Majoris with the Exosat, IUE, and IRAS satellites. Although several large ground-based observatories were prepared to make optical observations, they were all clouded out. The only point on this part of the spectrum was obtained by a variable star observer.

France Cordova of the Los Alamos National Laboratory in New Mexico and her colleagues at the Mullard Space Science Center Laboratory, University College, London, have used information from the AAVSO to augment X-ray and ultraviolet satellite data in 23 scientific papers. Cordova wrote about the key role amateur astronomers play: "The real discoveries of these stars belong to the men and women who keep vigil on them. In

In 1967 British astronomer and author Patrick Moore led a movement to unite amateur societies, but the effort failed (see box). Photograph by the author.

Why the IUAA Failed

Given the long-overdue need for more collaboration between professional and amateur astronomers, why has the International Astronomical Union not officially recognized a body of amateur astronomers and taken it under its wing?

The truth is it did. Little-known to many amateur astronomers, an effort was spurred on by the IAU 20 years ago to unite and coordinate amateur organizations globally. But it soon fell into political and financial disorder. Patrick Moore of Great Britain describes what went wrong:

"At the 1967 meeting of the IAU in Prague, it was suggested that we form an international union of amateur astronomers, to collaborate with clubs around the world in a way that hadn't been done before. I was asked to organize this.

"My idea was to have a yearly publication in which various societies would list what they do and what they publish. This was not in any way meant to overlap journals in existing national societies. In other words it was not meant to be a research organization at all, but merely a place to coordinate information.

"For two years I acted, frankly, as a complete dictator. Then the Italians volunteered to hold the first meeting in Bologna. We had all the agendas drawn up, and it was going very well. It was suggested that I become the first president. But this was an extremely bad idea, because I had done the initial organization. Instead, having gotten the effort off the ground, I thought it time to step down. So I did.

"We have had a couple of congresses since then, but the IUAA never in fact worked because it went off on a tangent. It tried to form various commissions to do actual work and publish papers. But there was no coordinated journal. There were also language problems, and there were financial problems, too.

"Unfortunately, nothing has been heard of the IUAA for the last two or three years. Many people have written to it, but they have gotten no answer from the secretary. And I have to say, with a great deal of regret, that it has not succeeded. It has had no impact whatsoever.

"We have to realize that we must start again. I'm saying nothing against anyone who was initially concerned with the old international union of amateur astronomers. But I'm afraid the results show that it did not work. That's a great pity, because there's a tremendous amount of good amateur work going on. It's published in national journals, but not coordinated. I feel there is urgent need here for it."

the future, as technology progresses even more, and as Hubble Space Telescope is launched, we will find that amateur astronomers will play a major role again."

BRINGING THE STARS TO THE PEOPLE

Philippe de la Cotardière, the newly elected president of SAF, emphasizes that in France there is great public interest in astronomy. But he sees an urgent need to inform the public of current astronomical events. He notes that the "natural fascination of the human mind is reinforced by the spectacular discoveries of the space program."

Furthermore, Cotardière stresses that beautiful books with panoramic views of the universe, as well as practical guides, can bring these results to a larger audience. But Christian Bourdeille, president of the Kepler Popular Astronomy Club in Gretz-Armainvilliers, France, would like to get to people when they're young. He believes astronomy clubs have to encourage and foster young minds through lectures. And he estimates that there are more than 60,000 amateur astronomers in France capable of the task.

Astronomy is tremendously popular in Japan, where for the last 20 years an annual Japan Amateur Astronomers' Convention has taken place. Its 18th meeting atop Mt. Azuma attracted over 1,000 people, many of whom said it was the first time they had seen stars in a dark sky.

But what of popularizing astronomy in less-developed nations, such as India? In 1977 Nehru Planetarium opened in Bombay, and to date 33 million people have visited it. Yet this staggering attendance figure must be qualified, admits Kunda V. Barve of the planetarium staff. "Though we aim to give scientific data," she explains, "the educational content is limited by the illiteracy of the viewers."

Barve cites specific problems that lead to this difficulty: a general lack of models, books, and money; a restriction in foreign exchange; an aloofness among professional astronomers toward teaching astronomy to the public; and a language barrier in multilingual Bombay.

GAINING RESPECTABILITY

Brian Marsden of the IAU's Central Bureau for Astronomical Telegrams cautions against jumping to hasty conclusions based on incomplete observations. He uses the purported "Aries" or "Perseus Flasher" as an example of good intentions gone awry. Marsden was "absolutely appalled to see this claim in a professional journal of the caliber of *Astrophysical Journal Letters*." Yet he praises Paul Maley, an experienced amateur astronomer from Houston, Texas, for his resolution of the enigma — the flashes were light glinting from artificial satellites (June issue, page 604). As Marsden observes, "There are competent amateurs and incompetent professionals, and that's what it's all about."

Would you realize what revolution is, call it Progress; and would you realize what Progress is, call it Tomorrow.
— Victor Hugo

Marsden summarizes the ways he believes amateurs contribute to astronomy.

- Visual: discoveries and magnitude estimates of comets, novae, supernovae, and variable stars; observations of mutual phenomena of Jupiter's satellites; measurements of double stars; recording sunspots and their motions; observations of artificial satellites, meteors, and transient features on planets.
- Photographic: discoveries, recoveries, and astrometry of comets and minor planets; studies of comets' nuclear regions and tail dissociations; double-star astrometry; solar eclipses; "near-miss" occultations of stars by the Moon; meteors.
- Photoelectric: variable stars.
- Spectroscopic: hydrogen-alpha observations of the Sun; radial-velocity measurements of solar flares.
- Video: occultations by the Moon, minor planets, and comets; solar eclipses.
- CCD Imaging: galaxies.
- Radio: meteors; the Sun.
- Computers: orbits of comets and minor planets; light curves; data bases.

Two of these areas were not really covered well at the meeting, according to Storm Dunlop, president of the British Astronomical Association. "One is planetary astronomy," he says, "where we like to think that we still make a contribution, and where perhaps professional astronomers do still have a certain prejudice against the amateur. Part of the problem lies with the amateur, who believes that since probes have explored Jupiter and Saturn, there's little to be done. Certainly, the BAA wants to continue to be very strong in planetary observation.

"The other topic," Dunlop continues, "is meteors. Again, this is something where the BAA has always made a very good contribution. It goes back to the days of William Denning, who was possibly the first person to suggest founding the BAA, and goes through people like John Prentice, to today's observers."

Dunlop returned to England with reams of scribbled messages about people he wants to contact. He reflects, "Personally, I've found it very, very useful, and I'm certain most of the other people who've been here will find exactly the same thing. There are too few meetings between amateurs and professionals."

Jean-Claude Pecker, president of the colloquium's scientific organizing committee, adds a philosophical note. "I am not quite sure what I am myself. Am I a professional? Well, I am paid to do astronomy, so I should be a professional. Am I an amateur? I think so, since I'm certainly doing it for my pleasure. But at the same time this is rather ambiguous.

"We professional astronomers spend the day writing reports, reading theses, attending meetings, and lecturing to people who sometimes really do not care what we lecture about. It's only very late in the evening that we are able to do astronomy for our pleasure. And I hope that in the coming years I will become less a professional and more an amateur."

STEPHEN JAMES O'MEARA

SAF Awards

The Société Astronomique de France awarded 12 medals to these amateur astronomers:

Paul Baize of France for his work on double stars.

Charles Boyer of France for his studies of Venus in ultraviolet light.

Jean Dragesco of France for his astrophotography and observations of the planets.

Robert Evans of Australia for his discoveries of supernovae.

Minoru Honda of Japan for his discoveries of comets and novae.

Janet Mattei of the United States for her leadership of the AAVSO.

Jean Meeus of Belgium for his astronomical computations.

Patrick Moore of Great Britain for popularizing astronomy.

Tsutomu Seki of Japan for his discoveries of comets and minor planets.

Oldrich Streda of Czechoslovakia for popularizing astronomy.

Renauld de Terwangue of Belgium for his numerous observations.

Jean Texereau of France for his telescope making.

S&T Test Report

OBSERVING WITH THE CAT

With this issue Sky & Telescope *introduces a new feature:* S&T *Test Report. More telescopes and accessories are on the market today than ever before. Many people can get them only by mail order, with no chance to examine them before buying. You've told us you want* Sky & Telescope *to review products, so here we go.*

We will make every effort to ensure that reviews are thorough, accurate, and trustworthy. Our procedure is to ask the manufacturer to lend us a unit and to supply a written guarantee that its performance is typical of those being sold. We then ask a carefully selected expert to put the unit through its paces, both in the field and on the test bench. When the review is completed the item is returned to the manufacturer. If the unit you purchase new does not match the performance described by the reviewer, you have the right to demand that the manufacturer repair or replace it.

First and foremost, our reviewers will assess whether the product lives up to the manufacturer's claims. But we'll also ask reviewers to cover the less obvious joys and disappointments you can expect if you buy the product. Remember, though, that the opinions expressed here are those of the reviewer and not of our editorial staff. Sky & Telescope *is interested only in informing our readers, not endorsing or maligning any product.*

In coming months we'll be reviewing items big and small, some expensive and some not. We are especially interested in featuring new products, those that have not had time to establish themselves as good or bad in the marketplace. —*The Editors*

NIGHTFALL. Time to put out the CAT. The Computer Aided Telescope, that is. This amazing device is one of the most useful (and expensive) observing accessories ever offered to amateur astronomers. It turns an ordinary telescope into a computerized wizard that, just a decade ago, would have made jaws drop at a professional observatory.

Suppose you want to find the galaxy NGC 891. Normally you might spend 10 minutes star-hopping toward it using charts, or almost as much time looking up its coordinates in a catalogue so that you could use setting circles. But with the CAT you just press a few keys to call up NGC 891 from its internal memory of more than 8,000 celestial objects. On the CAT's console an illuminated cross (in night-vision red) tells you where to point the telescope. The idea is to move the scope in the direction indicated until the arms of the cross shrink and disappear. This takes just a few seconds. You're now aimed at the object with an accuracy some 20 to 30 times better than is possible with most setting circles. It's so quick that you really *can* observe 100 objects an hour, as the ads say.

But the CAT offers more. Suppose you'd like to take a tour of every planetary nebula brighter than 11th magnitude and larger than 15 arc seconds. You also want them to be at least 30° above your horizon and appear "excellent" or "very good" visually (more about these ratings later). You enter in the parameters and the CAT directs you from one object to the next, displaying the vital statistics of each as you swing the scope around.

The CAT
Advanced Technology Instruments
P. O. Box 246
Carmel Valley, Calif. 93924
$1,495.00

Or suppose you'd like to scan the stars at random. Enter in the diameter of your telescope's field of view, sweep the scope around, and the CAT will beep every time a deep-sky object in its catalogue enters your field. The display tells how many objects are in the field at any given moment, and for the one nearest the center it gives the name, type, magnitude, size, visual quality (in a rating system from "excellent" to "very poor") and other information.

If ads for the CAT seem vaguely familiar, it's not surprising. One of the most talked-about new products in recent years is Celestron's computerized telescope. Long before it reached the market, people were abuzz with anticipation. At the touch of a few buttons, motors would slew the telescope to any celestial object in the unit's memory. As a matter of fact, the same person is behind both Celestron's device and the CAT: Mike Simmons, a long-time designer, builder, and user of telescopes and computers.

The main difference is that the CAT has no motors. You push the telescope by hand, which is fast, easy, and considerably cheaper than the motorized version.

INSTALLATION

The CAT has three main parts. There are two optical shaft encoders, a few inches across, that attach to the side and bottom of your Schmidt-Cassegrain fork mount. The third part is the CAT's heart: a computer not much larger than a hand-held calculator that attaches to the telescope tripod. In addition to its huge data bank, it contains sophisticated programs that help the user polar align and point the telescope.

The first instruction in the loose-leaf *User's Manual* is to read all 85 pages before installing the CAT. Considering my strong temptation to see the CAT work, this struck me as a tall order. Moreover, the manual turned out to be confusing in places — unlike the clear instructions presented by the CAT's display itself during operation. With some reorganization the manual could provide an enjoyable hands-on learning experience.

Installation is simple for those telescopes for which the CAT was designed: Meade and Celestron Schmidt-Cassegrains. I spent about 30 minutes attaching the encoders to a 10-year-old Celestron 8 with a die-cast mounting. The only tools required were a screwdriver and hex wrenches. But someone without mechanical aptitude might run into trouble. I had to read some of the manual's instructions two or three times before figuring out what they meant.

Users of other telescopes are left on their own. The manufacturer promises future versions of the CAT encoders for various types of mountings. (The current system could be adapted to German equatorials, but the red cross may direct you to move the scope so that it hits the mounting, since it indicates the shortest direction to an object. In this case you simply swing the scope the other way; the cross arms will adjust accordingly and still shrink as you approach your target. All information on the console display remains accurate.)

The next step is to adjust the telescope mounting, as described in the "First Night Out" chapter in the *User's Manual.* The CAT's potential to pinpoint objects is greater than the setting accuracy of most telescopes. In particular, the optical axis must be perpendicular to the declination axis, and the declination axis perpendicular to the polar axis.

Care in performing these adjustments is essential. It helps to have a crosshair eyepiece and an assistant, but even so the process can be tedious. After my initial attempt, I was not pleased with the CAT's ability to locate objects outside a small region of the sky. But after refining the adjustments, the CAT worked very well indeed.

Once everything is adjusted, the only limits to pointing accuracy are flexure in the mounting and looseness of optics (mirror flop). These effects will almost certainly be so small that the CAT can center anything in the sky reasonably well in a low-power eyepiece.

SETUP AND USE

These steps are all preliminary. The CAT itself is very easy to use. You quickly realize that it is human-engineered. Although each key on the console performs several functions, only one (indicated by an illuminated legend) is active at a time. The CAT walks you through each command sequence by lighting up only those keys appropriate at the moment. The keys are large enough to press with gloves on. A *back* key can undo an improperly entered command.

The *start* mode begins a night's observing session. It asks you for the Universal time, date, and latitude and longitude of your observing site. The CAT allows only valid numbers to be entered. For example, since the first hour digit of time can only be 0, 1, or 2, only these keys are active — you cannot enter, say, 7 by mistake.

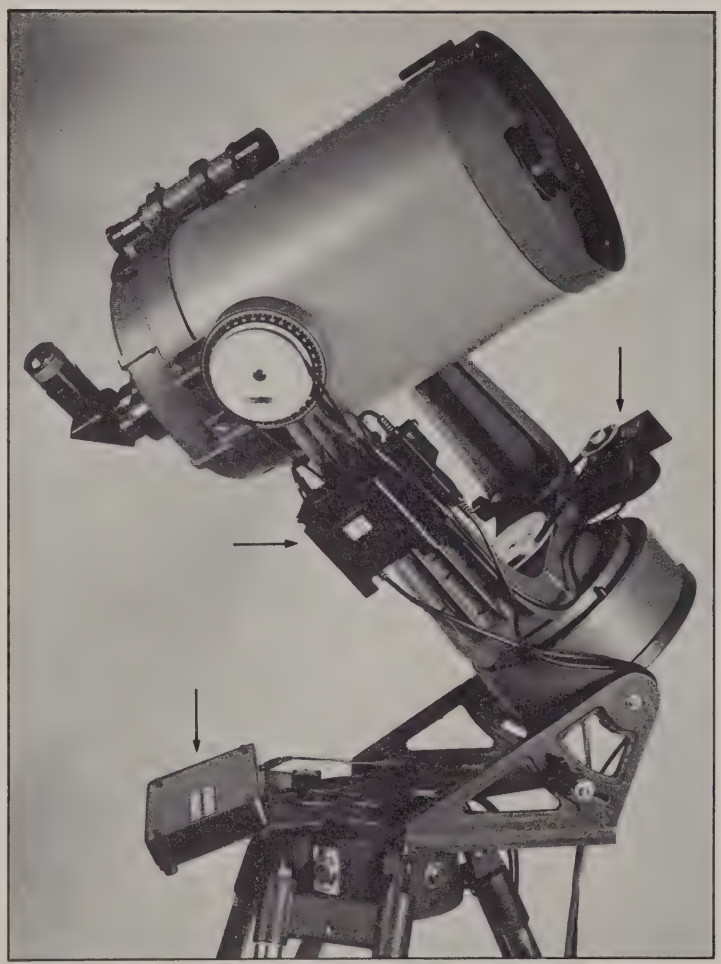
Next you index the shaft encoders by swinging the telescope in declination toward the celestial pole until the CAT beeps, and then in right ascension until it beeps as the scope crosses the meridian. It can beep at certain other positions during these steps, a minor annoyance that could be confusing since it's not noted in the *User's Manual.*

The CAT now helps provide quick and accurate polar alignment and setting of the encoders. You're led through a simple procedure using Polaris (or Sigma Octantis if you're at a Southern Hemisphere observing site) and a star near the meridian that the CAT automatically selects for you. In my case the CAT picked Antares, even though it was well past the meridian and only 16° above the horizon. It was hidden by trees.

My solution to this problem was simple. Brilliant Altair was near the meridian and high up. It took only a few keystrokes to call up data on Altair from the CAT's memory. With the star centered in the telescope's eyepiece I pressed the *sync* key. This key resets the coordinates of the CAT to those of the object shown on the console, and can be used anytime. It is especially useful to reset the encoders for different parts of the sky if the polar alignment or telescope adjustments mentioned above are inaccurate.

Now you're in business. The *CNGC, star,* and *M* commands select an object from either the CAT's Computerized New General Catalog (CNGC), a star list, or the Messier catalogue. After entering M101, for instance, two of the four arms of the red cross will light up — one for the east-west axis and the other for the north-south axis. The cross arms consist of 10 lights on each side of center. As you push the telescope toward the target along a given axis the corresponding arm shortens slowly at first, then faster as you near the target. The arms begin to shorten when you're about 8° from the object, but the last light goes out only when you reach the last 1 arc minute of declination or 0.1 minute of right ascension. Such motions take the merest touch on the telescope's side.

If you happen upon a nebulous object and hear no beep, you may have just swept up a comet.



For George East's tests, the CAT was attached to a Celestron 8 telescope with a 10-year-old mounting. Other mountings may require different fittings, so it is important to be specific when ordering the unit. You can call the manufacturer, Advanced Technology Instruments, to learn what instruments the CAT currently fits. Mechanically oriented people may be able to attach the CAT to *any* telescope. The CAT, which operates from either a 12-volt battery or house current (it consumes less than 10 watts of power), consists of two shaft encoders and the small computer console attached to the tripod.

In addition to the red cross, the console displays M101's brightness, size, type, visual quality, alternative catalogue designation (when applicable), and more.

The *next* and *back* commands allow you to scan through the three catalogues in numerical order. The *set* and *find* commands permit you to select classes of objects from the CNGC catalogue having almost any combination of attributes. You can avoid anything too near your horizon, too dim, and so forth. If you want to skip any object the CAT selects, just press *next* to move on.

The CAT offers too many other command combinations to be described here. A few of the more important are *field, display,* and *timer.* The *field* command instructs the CAT to beep when any deep-sky object is within your field of view and, if there are two or more, to identify the one nearest the center. It is fascinating to scan the heavens this way. If you happen upon a nebulous object and hear no beep, you may have just swept up a comet!

The command to *display* shows information in the CAT's memory, including celestial coordinates in any of three forms: right ascension and declination, hour angle and declination, or altitude and azimuth. These can be either for where the telescope is aimed or for the object shown on the display. The first option could be used to find an object not in the CAT's memory, such as a variable star, since it's a digital setting circle that updates as the scope is moved.

The *timer* command runs in increments of 0.1 second and can count up or down.

When counting down, the CAT will beep upon reaching zero, an excellent aid for timing photographic exposures.

For computer buffs, there's an optional RS-232 computer interface. Through this, an external computer could control the CAT or extract and print data from it. Many amateur telescope makers would probably like an optional accessory for interfacing stepper motors to drive the telescope, but none exists.

THE DATA BASE

Much effort has been devoted to the CAT's internal catalogues, which are also supplied as a printout. Since the CAT does not correct for precession, these catalogues will need updating in a few years. The memory chip is user-replaceable, and additions or corrections to the existing catalogues may be anticipated.

All three catalogues contain each object's equinox 1989.0 position, size, magnitude, and alternate designation if applicable. Codes tell the object's type, visual quality, and whether it is plotted on the Tirion *Sky Atlas 2000.0* or listed in *Sky Catalogue 2000.0*, Volume 2. The visual-quality rating of most objects was computed from their size, brightness, and type. But many were assigned by actual observation using a 14-inch telescope under dark skies.

The star catalogue contains information on 250 bright stars and 100 multiple stars. A nice addition would be a selection of variable stars, perhaps using the roster currently monitored by the AAVSO. Curiously, the printed catalogue lists some very nonstandard names (such as "CAT" and "booboo") for a few stars!

The CAT's Messier catalogue contains 110 objects. But M40, which is assigned to a double star in most versions of the Messier list I've seen, has been "revised." The CAT calls M40 the edge-on galaxy NGC 4565, admittedly a more interesting object.

The CNGC is structured around the *Revised New General Catalogue* (RNGC), published in 1973 by Jack Sulentic and William Tifft. The numbering of objects is nearly the same. The exceptions are substitutes for about 400 objects that were classified as "nonexistent" by the RNGC. The substitutes are usually interesting objects visible in amateur telescopes, but here the door has been opened wide to confusion. Fortunately, the catalogue (both the printed version and the information on the console display) tells whether a CNGC object is the same as the NGC object with the same number.

Like most new, large catalogues, the CNGC is very good but not perfect. For example, the object listed in the catalogue as NGC 3172 is clearly not the faint galaxy close to the north celestial pole. However, such errors are few enough that they don't compromise the CAT's effectiveness.

Overall the unit is quite well made, better than you might expect from the scruffy cartoon character who is the CAT's trademark. It won't damage or alter your scope if you ever wish to take it off. But the encoders may cause problems when you try to fit the scope into its original carrying case.

Although the CAT is a novel and complex product, it is easy to use once installed. Considerable effort has been devoted to its conception, design, and execution. Except for the few qualifications noted, the CAT performed as expected from its advertising. If you want to avoid objects that are too dim, or prefer to spend your time observing deep-sky sights rather than hunting for them, or just want to show friends the best the sky has to offer, then the CAT is ideal.

GEORGE H. EAST

George East is a longtime telescope maker and astrophotographer, and for many years has been on the Stellafane judging committee. He has a doctorate in mechanical engineering from the Massachussetts Institute of Technology.

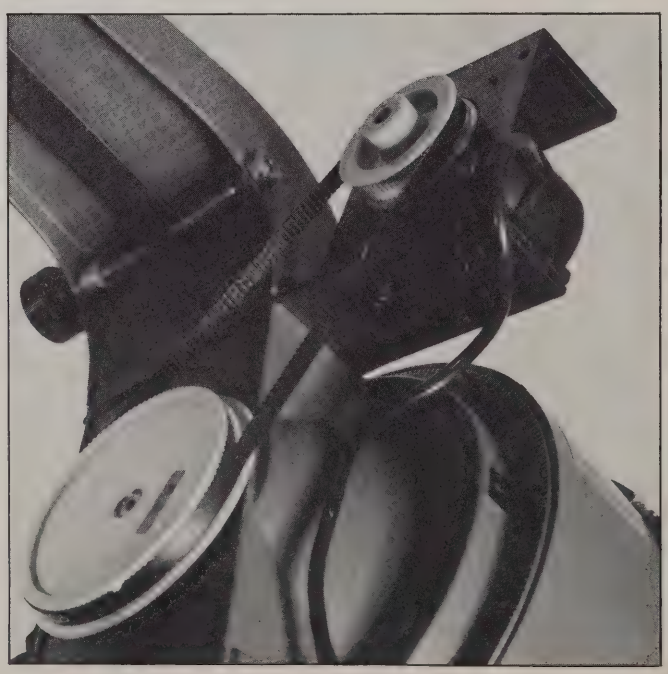
This time exposure of the CAT console, taken at night, shows information called up from memory on the spiral galaxy M101 in Ursa Major. It indicates a magnitude of 7.7 and a diameter of 26 arc minutes, along with other data explained in the text. Here the illuminated arms of the cross, which appear as a series of bars, are telling us the telescope must be moved slightly eastward and southward to center the galaxy in the eyepiece field. The entire display can be extinguished with two keystrokes if the glow proves annoying while observing.

Inside the CAT

For those who want the technical lowdown, the CAT recognizes 7,200 increments in a full rotation of each shaft encoder. As supplied, the pulleys and timing belts gear this up by 2:1 on the right-ascension (R.A.) axis and 3:1 on the declination (Dec.) axis. Thus a complete swing of the telescope around its R.A. axis is resolved into 14,400 parts (each equal to 0.1 minute of time), and around the Dec. axis into 21,600 parts (1 arc minute).

Lest anyone worry about the CAT "losing count," you'd have to slew the telescope more than 40° in a tenth of a second for this to happen! Interestingly, you can reprogram the CAT (by pressing a few keys during start-up) for use with pulley ratios different from those supplied. The *User's Manual* tells how this could simplify adapting the CAT to a homemade telescope.

The manual also explains in detail how an external computer, communicating serially with the unit at 9,600 baud, can do virtually anything that can also be done from the CAT's keyboard. More than 100 registers are accessible, containing such data as the key number last depressed and encoder counts. Only a person skilled in assembly-language programming could do much with this information.



A close-up of the right-ascension encoder shows its mounting bracket attached to the bottom of the fork arm. Note the pulleys (white) joined by a timing belt. Cables connect the encoders on both telescope axes to the computer console.

Books and the Sky

Conducted by Mollie D. Boring

ASTRONOMY TEXTS FROM ABELL TO ZEILIK

DO THESE PARAGRAPHS sound familiar to you?

Astronomy, being the study of the universe, deals with everything. No other science offers the student more contact with the rest of the sciences, history, and philosophy. No other subject, scientific or otherwise, challenges the imagination more. The flood of recent astronomical discoveries has generated widespread interest and made astronomy especially appealing at this time. All this is no doubt responsible for the steady increase in enrollment in introductory astronomy courses.

This text is designed for use in a one-semester course. The mathematics is kept to basic algebra, and no prior knowledge of physics is assumed. Technical terms are used only sparingly. Chapter topics are arranged in a natural order, beginning with the solar system and ending with the galaxies and cosmology. Color-plate sections enhance the beauty of the text and show the student some of the wonders of the universe.

What you have just read is not taken from a particular astronomy textbook. But read the preface of almost any introductory text on the market today, and you will probably feel a strong sense of déjà vu. This "generic" preface neatly summarizes the nature of the 27 texts covered in this review.

You probably fit into one or more of these four categories: professional astronomer, amateur astronomer, high school or college astronomy teacher, or astronomy student. Or perhaps you are just plain curious about astronomy. This review is designed for all of these, but particularly for the amateur and the instructor.

EDITOR'S NOTE

This month we depart from our usual book review format to present *The 1987* Sky & Telescope *Guide to Introductory Astronomy Textbooks,* a detailed look at the relative merits of more than two dozen texts. Harold P. Coyle, an experienced amateur astronomer and high school physics and astronomy teacher, prepared the *Guide* after spending all summer poring over the books. He is on sabbatical from Framingham North High School in Massachusetts and is working on Project STAR, an astronomy curriculum-development program at the Harvard-Smithsonian Center for Astrophysics (see page 452 of this issue for more on STAR).

If you are an amateur, especially if you are new to the hobby, you should assemble a good astronomy library for learning and reference. While there are books written specifically for the amateur, a selection of more general texts can be very useful.

Many amateur books concentrate on observing skills, instrumentation, and astrophotography. When an event such as the naked-eye Supernova 1987A occurs, you can find yourself inundated by the media with references to Type I and Type II supernovae, stellar evolution, and neutrinos. Your observer's handbook won't help you much with these topics. Weekly news magazines' coverage of science is often superficial, and *Sky & Telescope* only comes once a month. As another example, if you have been spending time observing the Galilean moons of Jupiter, you might like to know something about their physical characteristics.

If you have two or three good, recent texts on your bookshelf, you should be able to find the answers to your questions and references on where to look for further information. I say "two or three" because the coverage given a topic varies from book to book.

If you are an astronomy instructor, text selection probably has top priority. If you teach an established course, its content will determine the topics your book must cover. If you are developing a new course, examining different texts may help you set it up (some of them come with a teacher's manual that suggests various course outlines).

The information I consider helpful in choosing the right texts is listed in the chart on the next two pages. Most of the column headings suggest purely objective material, but there is a second layer of information that requires more explanation than a footnote offers.

THE TABLE

Column 1, ***Text,*** lists the authors and titles of 27 books. You may find that a book you know is missing from this roundup. That probably means it's out of date. Among recent works, only one omission is deliberate: George O. Abell's *Realm of the Universe.* Information on its status can be found at the end of the review.

(Text continued on page 490)

FOR YOUR ASTRONOMICAL BOOKSHELF

The Cambridge Atlas of Astronomy
— Audouze & Israel *63697* **$90.00**
The astronomy book to end them all. A gigantic (10½ x 14½ inches), exquisitely printed coffee-table encyclopedia. The 1,100 beautiful illustrations almost overshadow the 130 chapters of text, which by themselves are more substantial than many college textbooks. The ultimate gift book; years of browsing. *432 pages, hardbound.* (Level 2)

Space, Time, Infinity
— Trefil *48434* **$16.95**
This gorgeous coffee-table book surveys the history of astronomical thought from Babylonian times through the latest theories on the cause of the Big Bang. *225 pages, hardbound.* (Levels 1-2)

Comet
— Sagan & Druyan *49082* **$27.50**
Beautiful and lavishly produced, this large volume follows the courses of comets through human history and the lives of scientists. Will have lasting value. *398 pages, hardbound.* (Level 1)

Cosmos
— Sagan *02949* **$22.95**
A beautifully illustrated, masterful tour of the universe and the history of science. *365 pages, hardbound.* (Level 1)

Murmurs of Earth
— Sagan *et al.* *10475* **$15.00**
The story behind the phonograph record being carried by the Voyager spacecraft out of the solar system. *273 pages, hardbound.* (Levels 1-2)

The New Astronomy
— Henbest & Martin *10571* **$14.95**
A beautiful yet inexpensive guide to the universe as newly revealed in infrared light, X-rays, radio waves, and other wavelengths. *240 pages, large softbound.* (Levels 1-2)

The Search for Extraterrestrial Life: Recent Developments
— Papagiannis *21149* **$36.00**
Dozens of the world's researchers on this profound subject met in 1984 for a lively four-day symposium. This book is the proceedings of that meeting. Its 75 articles provide a firsthand look at scientists tackling an extraordinarily interesting subject. Technical but within range of *Sky & Telescope* readers. *579 pages, softbound.* (Level 3)

The Guinness Book of Astronomy
— Moore *24761* **$17.95**
Some records: the biggest, farthest, first, etc. *288 pages, hardbound.* (Level 1)

Beyond the Moon
— Maffei *31331* **$12.50**
An imaginary voyage through space to discover the kinds of objects that populate our universe both near and far. *377 pages, hardbound.* (Level 1)

Monsters in the Sky
— Maffei *31536* **$15.00**
Some mysteries of modern astronomy explored. *342 pages, hardbound.* (Level 1)

Level 1 = beginner, Level 2 = intermediate amateur, Level 3 = advanced. Use the order form in the center of this issue. Your order is shipped postpaid in the U. S.!

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, Mass. 02238-9102

THE 1987 *S&T* GUIDE TO INTRODUCTORY ASTRONOMY TEXTS

1 Text	2 Publication Data	3 Cost	4 Math	5 Physics	6 Teacher's Manual	7 Pages Text	8 Pages Index	9 Pages Glossary
Abell, Morrison, Wolff ***Exploration of the Universe***	Saunders College Publishing 1987, 5th ed., 3rd printing	H: $32.00	Alg.	None	Y	767	7	23
Berman and Evans ***Exploring the Cosmos***	Little, Brown & Co. 1987, 5th ed., 1st printing	S: $34.00	(Alg.)	None	Y	579	9	N
Dixon ***Dynamic Astronomy***	Prentice-Hall, Inc. 1984, 4th ed., 3rd printing	S: $39.00	(Alg.)	None	Y	555	13	10
Friedlander ***Astronomy: From Stonehenge to Quasars***	Prentice-Hall, Inc. 1985, 1st ed., 2nd printing	H: $42.67	Alg.	None	Y	589	13	15
Goldsmith ***The Evolving Universe***	Benjamin/Cummings Publishing 1985, 2nd ed., 1st printing	H: $39.95	Alg.	None	Y	562	7	15
Hartmann ***Astronomy: The Cosmic Journey***	Wadsworth Publishing Co. 1987, 3rd ed., updated	H: $38.50	(Alg.)	None	Y	553	14	16
Jastrow&Thompson ***Astronomy: Fundamentals and Frontiers***	John Wiley & Sons, Inc. 1984, 4th ed., 1st printing	H: $32.35	Alg.	None	Y	564	11	17
Kaufmann ***Discovering the Universe***	W. H. Freeman & Co. 1987, 1st ed., 1st printing	S: $24.95	None	None	Y,S	385	6	11
Kaufmann ***Universe***	W. H. Freeman & Co. 1985, 1st ed., 3rd printing	H: $34.95	(Alg.)	None	Y	594	9	10
Parker ***Concepts of the Cosmos***	Harcourt Brace Jovanovich 1984, 1st ed., 1st printing	H: $30.95	None	None	Y	516	8	7
Pasachoff ***Astronomy: From the Earth to the Universe***	Saunders College Publishing 1987, 3rd ed., 7th printing	S: $23.25	Alg.	None	Y,S	647	14	16
Pasachoff ***A Brief View of Astronomy***	Saunders College Publishing 1986, 1st ed., 6th printing	S: $19.95	None	None	Y,S	323	5	9
Pasachoff ***Contemporary Astronomy***	Saunders College Publishing 1985, 3rd ed., 5th printing	S: $22.95	None	None	Y,S	530	11	12
Protheroe, Capriotti, Newsom ***Exploring the Universe***	Charles E. Merrill Publishing 1984, 3rd ed., 1st printing	H: $36.95	(Alg.)	None	Y,S	586	14	12
Roy & Clarke ***Astronomy: Principles and Practice***	Adam Hilger (Taylor & Francis) 1982, 2nd ed.	S: $22.00	Calc.	Basic	N	342	5	N
Roy & Clarke ***Astronomy: Structure of the Universe***	Adam Hilger (Taylor & Francis) 1982, 2nd ed.	S: $22.00	Calc.	Basic	N	296	5	N
Seeds ***Foundations of Astronomy***	Wadsworth Publishing Co. 1986, 1st ed., updated	H: $38.50	(Alg.)	None	Y	608	12	13
Seeds ***Horizons: Exploring the Universe***	Wadsworth Publishing Co. 1987, 2nd ed., updated	S: $33.25	(Alg.)	None	Y	496	6	8
Shu ***The Physical Universe***	University Science Books 1982 (Sky Publishing)	H: $42.00	Alg. (Calc.)	Basic	N	584	12	N
Snow ***The Dynamic Universe***	West Publishing Co. 1985, 2nd ed.	H: $41.00	None	None	Y,S	598	6	12
Snow ***Essentials of the Dynamic Universe***	West Publishing Co. 1987, 2nd ed., 1st printing	S: $35.50	None	None	Y,S	538	6	11
Suggs ***Cosmic Frontiers***	Kendall/Hunt Publishing 1985, 1st ed.	S: $15.95	Alg.	None	N	195	3	N
Trejo ***Introductory Astronomy: The Solar System***	Kendall/Hunt Publishing 1986, 1st ed.	S: $39.95	Alg.	Basic	N	490	11	N
Unsöld & Baschek ***The New Cosmos***	Springer-Verlag New York 1983, 3rd ed., 1st printing	S: $33.00	Calc.	Adv.	N	479	21	N
Zeilik ***Astronomy: The Evolving Universe***	Harper & Row, Publishers 1985, 4th ed., 2nd printing	H: $33.50	(Alg.)	None	Y,S	494	10	10
Zeilik & Gaustad ***Astronomy: The Cosmic Perspective***	Harper & Row, Publishers 1983, 1st ed.	H: $39.50	Alg.	Basic	N	1001	14	21
Zeilik & Smith ***Introductory Astronomy and Astrophysics***	Saunders College Publishing 1987, 2nd ed., 1st printing	H: $33.75	Calc.	Basic	Y,S	503	19	N

Explanation of columns: **Y** = Yes, **N** = No, throughout the table. ***Column 1,*** **TEXT** is for a one-semester course. ***2,*** **PUBLICATION DATA** is for latest available edition. Several texts are due for early 1988 revision. ***3,*** **COST** is generally per single copy, and prices are for 1987; **H** is hardcover; **S** is soft. ***4,*** **MATH LEVEL** indicates algebra or calculus; if in parentheses, use is optional. ***5,*** **PHYSICS LEVEL** for high school or introductory college is Basic; for physics majors, Advanced. ***6,*** **TEACHER'S MANUAL** available; **S** means solutions worked out. ***10,*** **TOPICS** are listed in order they appear in text; numbers state how many chapters on the topic. **SS,** solar system; **OS,** outside the solar system; **HS,** history; **FD,** foundation material, such as observing, instruments, eclipses,

10 Topics	11 Activities/ Labs	12 Questions/ Problems	13 Chapter Summaries	14 Additional Reading	15 Star Charts	16 Reading Level	17 Concept Density	18 Figures	19 Sidebars
FD:1, HS:1, FD:9, SS:10, FD:3, OS:13, SP:1	Y,T	Y	N	A,T&P	Y	G	H	G,S	Y
FD:4, SS:5, OS:10, SP:1	N	Y	Y	C,P&T	Y	G	H	F,S	Y
HS:1, FD:1, SS:5, OS:14, SP:2	N	Y	N	N	Y	G	M	F,S(I)	N
HS:1, FD:1, HS:1, FD:6, SP:1, SS:8, OS:11, SP:1, OS:1	N	Y	Y	A,P&T	Y	G	H	G,S	Y
FD:3, OS:7, SS:3, SP:1	Y,T	Y	Y	C,P&T	Y	G	H	F,S&I	N
HS:1, FD:1, SP:1, FD:1, SS:1, FD:2, SS:5, OS:13, SP:1	Y,T	Y	Y	A,T&P	Y	G	H	G,S&I	Y
FD:6, OS:7, SS:6, SP:1	N	Y	Y	N	Y	G	H	P,S	N
FD:5, SS:5, OS:9	Y,M	Y,A	Y	C,T&P	Y	G	H	G,S	N
FD:5, SS:11, FD:1, OS:11, SP:1	N	Y,A	Y	C,T&P	Y	G	M	G,I	Y
HS:1, FD:4, SS:7, OS:13, SP:1	Y,T	Y	Y	C,P&T	Y	G	M	F,S	Y
FD:5, SS:11, SP:1, OS:15	Y,M	Y,A	Y	A,T&P	Y	G	H	G,S	Y
FD:4, SS:9, SP:1, OS:14	Y,M	Y	Y	A,P&T	Y	G	M	G,S	Y
FD:3, OS:14, FD:1, SS:9, SP:1	Y,M	Y,A	Y	A,T&P	Y	G	M	G,S	Y
HS:1, FD:6, SS:3, OS:9	N	Y,A	Y	A,P&T	Y	G	H	F,S	Y
FD:21	Y,T	Y,A	N	A,T&P	N	T	H	G,S	N
SS:4, FD:1, SS:1, FD:1, OS:10, SP:1	Y,T	Y,A	N	A,T&P	N	T	H	F,S	N
FD:9, OS:10, SS:6, SP:2	Y,T	Y,A	Y	C,T&P	Y	G	H	F,S	Y
FD:5, OS:8, SS:4, SP:2	Y,T	Y,A	Y	C,T&P	Y	G	H	F,S	Y
FD:4, OS:12, SS:2, SP:2	N	Y	N	N	N	G(T)	H	G,S	Y
FD:2, HS:1, FD:4, SS:11, OS:14, SP:1	N	Y	Y	C,P&T	Y	G	M	F,S	Y
FD:4, SS:8, OS:11, SP:1	N	Y	Y	C,P&T	Y	G	M	G,S(I)	Y
HS:2, FD:4, SS:5, OS:5, SP:2	Y,W	Y	N	N	Y	G	M	F,S	N
FD:7, SS:7, SP:2	N	Y	N	A,T&P	N	G	M	P,S	N
HS:1, FD:5, SS:2, FD:1, HS:1, OS:10, HS:1, OS:8, SP:1 SS:1, SP:3	N	N	N	A,T&P	N	T	H	G,S	N
FD:1, HS:1, FD:5, SS:5, OS:9, SP:1	N	Y	Y	C,P&T	Y	G	M	G,S(I)	Y
FD:1, HS:1, FD:3, OS:1, FD:1, OS:5, SS:7, OS:5, SP:3	N	Y	Y	C,P&T	Y	G(T)	H	G,S	Y
FD:3, SS:4, FD:2, OS:15	N	Y	N	A,T&P	N	G(T)	H	G,S	N

Kepler's Laws; **SP,** special topics, such as SETI, space travel. ***11,*** **ACTIVITIES/LABS,** if in text = **T;** workbook = **W;** teacher's manual = **M.** ***12,*** **QUESTIONS/PROBLEMS: A** means answers provided for some questions in text. ***14,*** **ADDITIONAL READING: C** = for the chapter, **A** = in appendix; **T** = technical literature, **P** = popular. ***15,*** **STAR CHARTS** are for northern sky only. ***16,*** **READING LEVEL: G** = general or high school level; **T** = technical language. ***17,*** **CONCEPT DENSITY** is rate new material introduced; **H** = high, **M** = medium. ***18,*** **FIGURES,** rated by quality of visual impact: **G** = good, **F** = fair, **P** = poor; **S** means standard treatment, **I** innovative. ***19,*** **SIDEBARS** are supplementary material set apart from the main text.

THE MOST FASCINATING STARS IN THE UNIVERSE ARE OFTEN AT THE OTHER END OF THE TELESCOPE.

Astronomers—specifically, those working at southern California's acclaimed Palomar Mountain—are the subject of Richard Preston's unique *First Light*.

Since the Hale Telescope at Palomar opened its shutter to "first light" in 1949, the observatory has been a mecca for generations of astronomers and remains to this day the largest optical telescope in the Western world. In *First Light*, Richard Preston has produced a fascinating account of the place and the institution, and of astronomy and the people who practice it.

"Humane, admiring, and always witty....Preston's prose is precise and elegant, and he has an eye for character and analogy that equals the best work of anyone writing nonfiction today. *First Light* is an enchanting work."—Verlyn Klinkenborg, author of *Making Hay*

ATLANTIC MONTHLY PRESS

A Morgan Entrekin Book

Atlantic Monthly Press books are distributed by Little, Brown and Company (Inc.)

Observe Preston's stellar achievement for yourself.
$18.95 now at your bookstore or use coupon to order

Please send me _____ copy(ies) of *First Light*. I enclose my check/money order for $18.95 plus $1.50 for postage and handling

Name_____

Address_____

City_____ State_____ Zip_____

Please send coupon to:
The Atlantic Monthly Press, Box JK
19 Union Square West, NY, NY 10003
Or to order by phone call 800-343-9204

(Continued from page 487)

Texts in this list have an elementary, one-semester format, though some are also appropriate for a one-year course. They are all actively in print. Despite appearances, no authors received special attention; Jay M. Pasachoff and Michael Zeilik appear three times each because they happen to have that many texts out. I do not review laboratory manuals, workbooks, self-teaching guides, or texts covering specialized areas.

The most rigorous text is Albrecht Unsöld and Bodo Baschek's *The New Cosmos*. It is clearly not an introduction for nonscience students. It does, however, cover all major topics in astronomy and was included as an excellent book for the serious amateur who has a background in physics and calculus.

Column 2, ***Publication Data,*** provides sufficient information for acquiring a copy of the book. It also shows a text's age — only those revised as of 1982 are included. This is the "Voyager limit." By the end of 1981, both spacecraft had passed Saturn, and works printed after that year contain Voyager data on Saturn, its rings, and satellites. Substantial amounts of new information from solar system probes were not obtained again until early 1986, with the Voyager 2 flyby of Uranus and the flybys of Comet Halley. Some of this information can be found in the "1987" volumes. However, none of them mentions SN 1987A. Those due out in new editions in late 1987 and early 1988 should feature the supernova. They are discussed at the end of the review.

Column 2 also lists editions and, where known, printings. In general, a text improves with subsequent editions. A first edition, especially by a previously unpublished author, is likely to be somewhat experimental, containing some ideas the writer has never before tried in print. Similarly, the first printing of any edition tends to contain more errors in text or illustrations than later printings.

Column 3 lists the publisher's retail price as of July 1, 1987, and tells whether the text is hardcover or softcover. As far as I could determine, the books are only available in the binding type indicated; there are no softcover versions of the hardcover editions. However, two of the hardcover works have been adapted into shorter, less costly, softcover versions. They are William J. Kaufmann's *Discovering the Universe* (adapted from his *Universe*) and Theodore P. Snow's *Essentials of the Dynamic Universe* (an abridged version of *The Dynamic Universe*).

Since many publishers print their topline texts in softcover, the prospective buyer should not automatically consider such a book as something "less" than a hardcover. The cost and durability of binding may be less, but not inevitably. Note, for example, the high price for Paul E. Trejo's softcover *Introductory Astronomy: The Solar System,* which has a companion volume on stars, galaxies, and the universe due out in the near future.

Columns 4 and 5 indicate the assumed math and physics background of the reader. Most of the volumes are geared toward freshman college students and use basic algebra, though a few present some calculus in special sections. Six of the texts are so fundamental that they do not require *any* algebra background; three of them are the abridged versions by Kaufmann, Pasachoff, and Snow. Only four have an integrated use of calculus.

Since few nonscience college freshmen have had any physics in high school (many schools do not even offer it, and it is an elective in virtually every school that does), most authors introduce and develop what physics they need. Only *The New Cosmos* assumes a thorough knowledge of physics, which a college freshman would have only if he or she had taken an advanced-placement course in high school.

For instructors, column 6 notes the availability of teacher's manuals, which were not provided for examination with all the texts. (Most publishers only send a manual when a course book order is placed.) The ones I saw were generally quite thorough in outlining the use of the text and working through problem solutions. Some manuals are virtually books in themselves, and a few are written by someone other than the textbook author. The most extensive were for the three Pasachoff volumes, which offered sample course outlines, test questions, laboratory activities, movie transcripts, and bibliographies. Several of the textbooks, including those by Snow, Kaufmann, and Pasachoff, have companion transparencies, slide sets, or both.

Columns 7, 8, and 9 demonstrate how easy it might be to use the text as a general reference. ***Pages Text*** gives the book's total length, including appendixes, glossary, and index (but not table of contents or preface). ***Pages Index*** suggests how readily information might be found; the longest book does not have the longest index. Index formats vary considerably, making the number of pages less than an ideal guide.

Pages Glossary should be considered in the same manner as ***Pages Index,*** with the one difference that all texts do not have glossaries. A thorough index can function as a glossary of sorts, giving you a page or pages where a particular term can be found, but it is far more convenient to turn to a word in a glossary and get its basic definition. If you are looking for a work to serve as a quick reference, I

recommend getting one with a glossary, especially if it is going to be your first or only astronomy book.

Column 10, ***Topics,*** outlines the organization of the texts. The number of chapters for each of five topic areas is listed in the order in which they appear. Some chapters contain a mix of topics; in such cases, the dominant theme was selected. *FD* indicates foundation material, which includes basic physical laws (such as Newton's and Kepler's), eclipses, tides, instrumentation, and the major discoveries of Copernicus, Tycho Brahe, Kepler, Galileo, and Newton. *HS* (history) covers discussions of ancient astronomy and the work of astronomers who are not mentioned above.

The universe was divided into two topics. *SS* (solar system) includes all material on the planets, their moons, comets, asteroids, and meteors. *OS* is everything outside the solar system. Where does the Sun fit in? Most texts discuss it under the heading of "stars," often using it as a model for a star. Therefore I allotted chapters on the Sun to the *OS* category. As textbooks generally have only one chapter on the Sun, you can safely subtract it from *OS* and add it to *SS*.

OS usually follows *SS,* and the first *OS* chapter is almost always the one on the Sun. *OS* otherwise includes spectral classification of stars, stellar evolution, the interstellar medium, the Milky Way, other galaxies, and cosmology. Finally, *SP* stands for special topics, including extraterrestrial life, UFO's, astrology, and environmental concerns.

A majority of the texts use the "traditional" topic organization, beginning with a mix of history and foundation material, then proceeding from the planets nearest the Sun on out to the galaxies and the structure of the universe, saving special topics for last. A number of books, however, start with the most distant parts of the universe and work their way in toward the solar system.

The traditional sequence follows the development of acquired astronomical knowledge: we learned about the solar system before we learned about the galaxies. The "reverse" order establishes the structure of the universe first and then fits the solar system into it, giving the student a better feeling for Earth's place in the universe. Each pattern has its own merits, and the "best" approach is a matter of personal choice.

Teachers may find the information in columns 11 and 12 of special interest. Column 11 shows whether the text supplies any laboratory work or activities. Thirteen of them do, but only eight include the material in the text itself. The exercises may be simple but thought-provoking observational activities. Donald

Astrophotography Exposure Guide

Bound edition, 55 pages (8½" x 11"), includes exposure tables for Sun, solar eclipse, Moon, planets, and more. Eliminates guesswork so you save time and film. Useful for all, but a must for beginners! Mail check or money order for $10.95 ($12.95 by 1st class mail, foreign; $14.95 by airmail) to:

ASTRONOMICS (Since 1972)
227 Linwood St., Lynn, Mass. 01905
Phone: 617-598-3378

NO SHIPPING CHARGE ON CELESTRON TELESCOPES

- Powerstar 8 w/Starbright, w, t, $1,595 (ltd qty)
- Super C8 Plus w/Starbright, w, t, $1,495 (ltd qty)
- Generous discounts for accessories
- Personal checks accepted
- Send stamped envelope for price list

AN EXCITING NEW BOOK!!!
RADIO ASTRONOMY, 2nd ed.
by John D. Kraus
Ohio State University

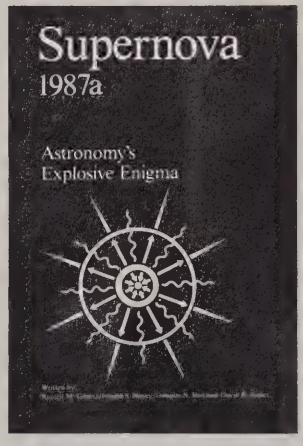
The classic teaching text and reference book which has served a generation of the world's radio astronomers, now in a much enlarged, updated edition. With hundreds of new illustrations, problems, worked examples and references. 710 pages. $39.95. Shipping $1.60 U.S., $2.50 elsewhere.

CYGNUS-QUASAR BOOKS
P.O. Box 85, Powell, Ohio 43065
Tel. (614) 548-7895

SUPERNOVA 1987a

Astronomy's Explosive Enigma

You've read the highlights of the discovery of SN 1987a in newspapers and magazines. Now you can get the full story in this new book from Fairborn Press. Follow the evolution of massive stars from birth to explosive death. Hear the human story. Meet the people involved in the discovery and in the endeavor to understand this unusual supernova. Over 100 illustrations. Hardbound. 250 Pages.
ISBN 0–944389–01–5 $23.95



NEW GENERATION SMALL TELESCOPES

Telescope Design, Telescope Automation, Photometry, Spectroscopy, Space Telescope. Over 400 pages. Over 100 figures. Softbound.
ISBN 0–944389–00–7. $23.95

PHOTOELECTRIC PHOTOMETRY HANDBOOK

History of Photometry, Equipment for Photometry, Photoelectric Observations, Observing Programs. 205 pages. Softbound.
ISBN 0–911351–09–4 $23.95

AUTOMATIC PHOTOELECTRIC TELESCOPES

APT Results, Automated All Sky Photometry, Automated Spectroscopic Telescopes, Automated Supernova Searches. Softbound.
ISBN 0–944389–00–7 $23.95

OTHER TITLES

–Microcomputers in Astronomy. $23.95
–Microcomputers in Astronomy II. $23.95
–Advances in Photoelectric Photometry. $23.95
–Advances in Photoelectric Photometry II. $23.95.
–The New Zealand Symposiums on Photoelectric Photometry. Vol. I $9.95. Vol II $15.00.

SUBTOTAL_____
AZ RES TAX 6%_____
HANDLING $1.50
TOTAL_____
NAME_____
ADDRESS_____
CITY_____
STATE_____
ZIP_____

FAIRBORN PRESS
P.O. BOX 7531
MESA. ARIZONA 85206

Goldsmith's *The Evolving Universe* contains a number of these, including naked-eye examination of the Milky Way and binocular viewing of the Orion nebula and visual double stars. Goldsmith has worked his activities into the text, offering an assortment at the end of each chapter.

More involved, laboratory-style work tends to be found in teacher's manuals. Pasachoff offers five labs developed by the Astronomy Program at the University of Maryland in his manual for *Contemporary Astronomy.* Two of these involve Palomar Sky Survey photographs and can be expanded upon to the point where the students are duplicating the type of work done by professional astronomers. (Pasachoff recommends the use of original photographs, though he provides printed copies in the manual.) William W. Suggs's *Cosmic Frontiers* has a 90-page companion workbook that provides pencil-and-paper exercises.

Column 12 shows that all but one text (*The New Cosmos*) include chapter questions and problems and that one-third of the books also provide answers. These usually answer odd- or even-numbered questions only, giving just numerical results to check against.

Chapter Summaries (column 13) suggests how well the text may guide the student in what is supposed to have been learned in a given chapter. One of the best works in this respect is Zeilik's *Astronomy: The Evolving Universe.* He starts each chapter with a list of objectives, italicizes key words, and provides key concepts at the end of the chapter.

Additional Reading (column 14) shows that all but five of the books point the way to further sources of information. The format that offers the most detail is the chapter-end reading list. *P* and *T* denote "popular" and "technical" references, respectively. Since all reading lists contain both types, the notation *P&T* means more popular than technical, while *T&P* means more technical than popular. Popular periodicals include *Sky & Telescope, Astronomy, Mercury, Scientific American,* and *National Geographic. Science, Nature,* and *Annual Reviews of Astronomy and Astrophysics* are examples of technical publications.

Column 15, ***Star Charts,*** tells whether or not texts contain maps of the night sky. These are commonly printed on the inside of the covers or as a set of seasonal or monthly charts at the end of the book. They tend to be more decorative than useful, as it is not very convenient to manipulate a bulky book over your head in the dark.

Reading Level (column 16) considers the use of technical terminology, assumed vocabulary, and complexity of sentence and paragraph structure in arriving at a general (*G*) or technical (*T*) rating. General is presumably the reading ability of a high school graduate. Technical is for the reader familiar with scientific literature or possessed of a nimble mind and an extensive English vocabulary. The three texts with *T* in parentheses tend to start out at a general reading level, add technical terminology along the way, and gradually work the reader up to a fairly high level.

Concept Density (column 17) indicates the rate at which new material is introduced in each chapter. This characteristic should be seriously considered if the book is being selected for a course. Everything else about a text may be "basic" and well laid out, but if the target students are those not majoring in science, the book could still fail them miserably by packing new and unfamiliar concepts too closely together. I selected one of the simplest ways of measuring concept density: how many new terms or concepts are introduced in a chapter? One to six was low (*L*); seven to 12, medium (*M*); and 13 or more, high (*H*). Significantly, all the texts reviewed here turned out to have medium or high concept densities.

Column 18, ***Figures,*** is perhaps the most subjective listing in the chart. It covers all illustrations in a volume, from color plates to simple line drawings and tables. The good, fair, or poor ratings represent the average within the textbook.

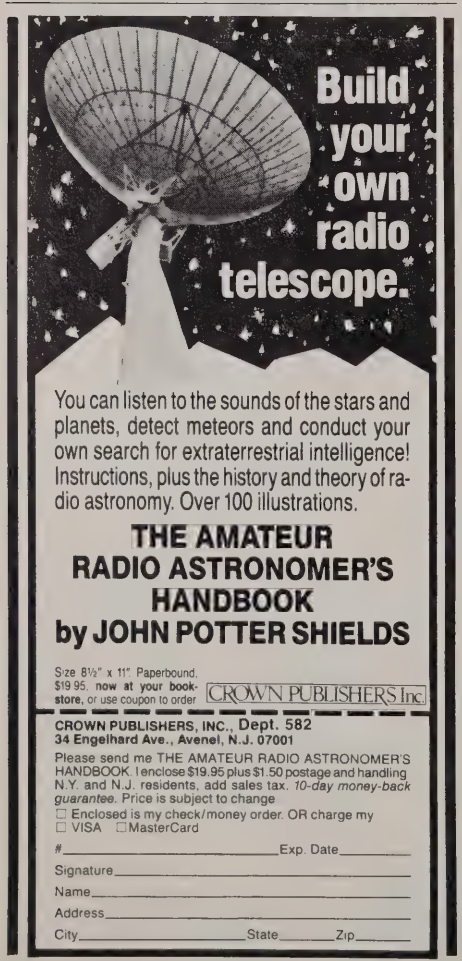
Tables, charts, and graphs should be clear and well captioned. Diagrams ought to stand out to the reader. Nothing is worse than the trend among some publishers to turn diagrams that could be executed in crisp black-and-white layouts, with perhaps a second color to set off some of the lines, into sets of lines of various hues of the same color against colored backgrounds. For example, Robert Jastrow and Malcolm H. Thompson's *Fundamentals and Frontiers* has four-color diagrams based on black, white, blue, and gray. The shades of blue and gray vary from drawing to drawing and within drawings; the fine white lines become difficult to see against a light-blue background.

Color plates are extremely popular now, and most of the books have several sections of them spaced throughout. After looking at 27 texts, however, I would have a difficult time identifying a specific one by its color-plate sections: the same sets of photographs appear in every book. Most publishers simply make use of stock NASA and Palomar photographs.

Aside from unique pictures, such as the discovery photo of Io's volcanic activity, I would think some searching could be done to give a text more individuality. The color-plate-section syndrome could be broken, too, by putting the photographs with the material they relate to; Snow's *Essentials of the Dynamic Universe* is set up this way and is a very colorful volume.

Figures are also rated as standard (*S*) or innovative (*I*). By looking down column 18 you can see that standard means the usual figures appear in the texts. Innovative indicates an attempt at creativity by either the author or the publisher. Examples of true novelty can be found in the books by William K. Hartmann and by Robert T. Dixon. Some of Hartmann's own original paintings of astronomical subjects have been reproduced in black and white in his *Astronomy: The Cosmic Journey.* Dixon's *Dynamic Astronomy* contains eight clever flip-page sequences of diagrams, printed along the upper, outer margins of the text. The simple cartoon animations, achieved with the flick of your thumb against the edges of the pages, let you view a few selected "movie shorts," including cometary orbital motion, a binary star system, and planetary retrograde motion.

The last column, ***Sidebars,*** tells whether or not the author has included supplementary material offset in boxes or on separate pages. Sidebars may contain anecdotes, biographical information, special problems, or other material not directly a part of a chapter. They can liven up a text and provide subject matter for class discussions or assignments.


Build your own radio telescope.
You can listen to the sounds of the stars and planets, detect meteors and conduct your own search for extraterrestrial intelligence! Instructions, plus the history and theory of radio astronomy. Over 100 illustrations.
THE AMATEUR RADIO ASTRONOMER'S HANDBOOK
by JOHN POTTER SHIELDS
Size 8½" x 11". Paperbound. $19.95. now at your bookstore, or use coupon to order
CROWN PUBLISHERS Inc
CROWN PUBLISHERS, INC., Dept. 582
34 Engelhard Ave., Avenel, N.J. 07001
Please send me THE AMATEUR RADIO ASTRONOMER'S HANDBOOK. I enclose $19.95 plus $1.50 postage and handling. N.Y. and N.J. residents, add sales tax. 10-day money-back guarantee. Price is subject to change
☐ Enclosed is my check/money order. OR charge my
☐ VISA ☐ MasterCard
#_____ Exp. Date_____
Signature_____
Name_____
Address_____
City_____ State_____ Zip_____

UPCOMING EDITIONS

While this review was being prepared, *Sky & Telescope* received publishers' announcements of upcoming revisions of some of the books considered here. So that you may have the most current information, here are the revisions of which I have been made aware as of September.

First, let me take care of the chart omission of Abell's *Realm of the Universe.* This is due out in its fourth edition in December, 1987. I do not have the details on how much it will change from the 1984 version, but it is bound to be somewhat different. Abell died about the time the third edition was released. The new edition will have Abell, David Morrison, and Sidney C. Wolff as authors, and it will be available from Saunders College Publishing. The authors asked us to omit the third edition from the survey.

Other texts due out in new editions are:

• Kaufmann's *Universe*, second edition, in December, 1987. A letter from Kaufmann states the new edition will look like the first but be about 50 pages longer. Many black-and-white photographs are being replaced by color. The number of chapters and the topic sequence are essentially unchanged, but new material on Uranus and Comet Halley will be added. There will also be an expanded discussion of Type I versus Type II supernovae. The chapters on the solar system are being trimmed of "extraneous material." Discussion of light, atomic structure, and the electromagnetic spectrum will be consolidated. There will be more material on galactic structure and evolution.

• Snow's *The Dynamic Universe,* third edition, by the end of 1987 or early 1988. It will incorporate new material on Uranus and Comet Halley, as well as on cosmology, and include a several-page insert on SN 1987A. The review questions will be rewritten with problems added. A new feature will be summary tables of data throughout the text.

• Zeilik's *Astronomy: The Evolving Universe,* fifth edition, in December, 1987, or January, 1988. Zeilik tells me that the new edition will have 22 chapters, with material on Uranus and Comet Halley. A light curve for SN 1987A through May 13, 1987, is to be included as well. Some activities will be added throughout the text. The line art has been simplified, and drawings will appear in two colors.

No single text in this review can be recommended as The Best. Given all the variables involved in selecting a book for a particular purpose, no one could conceivably fit the needs of every reader. I hope, however, that you now find yourself supplied with enough information to choose your own "best text." Good luck!

HAROLD P. COYLE

Briefly Noted

The volumes listed in this column may be purchased directly from the publishers indicated. Unless so noted, they are not available from Sky Publishing Corp.

Lines to the Mountain Gods: Nazca and the Mysteries of Peru, Evan Hadingham, 1987, *Random House.* 307 pages. ISBN 0-394-54235-5. $22.50.

Modern scientific theories of the origins and purposes of the lines and figures on the Nazca desert are set against the broad background of Andean culture in this well-illustrated book.

Space: The Next Twenty-Five Years, Thomas R. McDonough, 1987, *Wiley.* 237 pages. ISBN 0-471-85671-1. $17.95.

A former Jet Propulsion Laboratory scientist discusses the hopeful prospects for future space exploration. Interspersed with quotes and partial essays by noted space advocates, the text covers a wide range of related topics including the history of space exploration, the human-versus-robot controversy, and the Strategic Defense Initiative.

Mars 1999, Brian O'Leary, 1987, *Stackpole Books,* P. O. Box 1831, Harrisburg, Pa. 17105. 160 pages. ISBN 0-8117-0982-5. $14.95.

Subtitled "Exclusive Preview of the U. S.-Soviet Manned Mission," this work is the personal vision of a planetary scientist and former astronaut. Most space planners consider piloted missions to Mars unthinkable before the 21st century, but in this account O'Leary maintains that by early 1999 a cosmonaut-astronaut team could drop onto the red planet from a staging area on its moon Phobos.

Deep Black: Space Espionage and National Security, William E. Burrows, 1986, *Random House.* 401 pages. ISBN 0-394-54124-3. $19.95.

By tacit agreement, both superpowers have quietly placed tremendous emphasis on spy satellites in their programs of national surveillance. This book documents the history of overhead military reconnaissance, its status today, and the crucial role it will play in verification of treaties. The story is told with gratifying depth and breadth, even though the author garnered most of his information from open sources.

Astronomy and Astronautics: An Enthusiast's Guide to Books and Periodicals, Andy Lusis, 1986, *Facts On File, Inc.,* 460 Park Ave. S., New York, N. Y. 10016. 292 pages. ISBN 0-8160-1469-8. $24.95.

This is an extensive, well-organized guide to popular astronomy and space-exploration publications since 1976, indexed by author, title, and subject. It is a chronological continuation of Robert A. Seal's *A Guide to the Literature of Astronomy,* 1977. Each of the nearly 1,000 entries includes a full bibliographic citation and a paragraph of description.

Sternbilder, Sternsagen: Mythen und Legenden um Sternbilder, Angel Bonov, 1986, *Urania-Verlag,* Salomonstrasse 26-28, DDR-7010 Leipzig, East Germany. 288 pages. ISBN 3-332-00031-4. DM 24.00, or about $13.25.

Constellations, Starlore is a German translation by Leo Korniljew of a work originally published in Bulgarian as *Myths and Legends of the Constellations.* It describes in considerable detail how stars and asterisms acquired their names. Diagrams depicting present-day constellations complement reproductions of Hevelius' ornate 17th-century sky charts.

Ancient Astronomy and Civilization, Norriss S. Hetherington, 1987, *Pachart Publishing House,* P. O. Box 35549, Tucson, Ariz. 85740. 187 pages. ISBN 0-88126-225-0. $26.00, paperbound.

A once-over of astronomy and its relation to human thought from Stonehenge to the Greeks, with the emphasis on the latter. Much of the text consists of excerpts from the writings of ancient astronomical thinkers.

Soviet Space Programs: 1980-1985, Nicholas L. Johnson, 1987, *Univelt, Inc.,* P. O. Box 28130, San Diego, Calif. 92128. 288 pages. ISBN 0-87703-266-1; $55.00, cloth. ISBN 0-87703-267-X; $45.00, paper.

Volume 66 in the American Astronautical Society's Science and Technology Series covers the period 1980-85 and brings together information from a wide spectrum of Russian-language and unclassified U. S. literature. It complements two previous books by the author that methodically detail the Soviet space program through 1979.

The Space Station: A Personal Journey, Hans Mark, 1987, *Duke University Press,* 6697 College Station, Durham, N. C. 27708. 264 pages. ISBN 0-8223-0727-8. $24.95.

An intimate, first-person account takes readers on a grand tour of American space policy. The author, who served as NASA's deputy administrator from 1981 to 1984, briefly recounts early ideas about space stations. But his focus is the five-year period from the Space Shuttle's debut, through hard-fought policy battles behind the scenes, to the eventual approval of NASA's space-station plan in the mid-1980's.

Schrödinger: Centenary Celebration of a Polymath, C. W. Kilmister, editor, 1987, *Cambridge University Press.* 253 pages. ISBN 0-521-34017-9. $54.50.

This collection of essays covers the life and work of Austrian scientist Erwin Schrödinger (1887-1961). His contributions to fields as diverse as cosmology, physics, chemistry, and biology are described by 19 experts.

The Astronomical Almanac for the Year 1988, Nautical Almanac Office, 1987, *U. S. Naval Observatory* (order from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, as Stock No. 008-054-00131-9). 536 pages. ISBN 0-11-886929-9. $23.00. Include check or money order.

Astronomical Phenomena for the Year 1989, Nautical Almanac Office, 1987, *U. S. Naval Observatory* (order from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, as Stock No. 008-054-00125-4). 73 pages. ISBN 0-11-886927-2. $3.00, paperbound. Include payment.

Late Stages of Stellar Evolution, S. Kwok and S. R. Pottasch, editors, 1987, *Reidel.* 426 pages. ISBN 90-277-2446-6. $79.00. Proceedings of a workshop held in June, 1986.

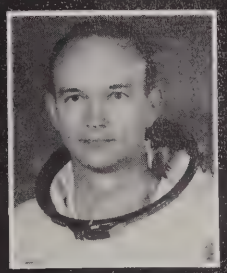
Physical Processes in Comets, Stars, and Active Galaxies, W. Hillebrandt, E. Meyer-Hofmeister, and H.-C. Thomas, editors, 1987, *Springer-Verlag New York.* 193 pages. ISBN 0-387-17766-3. $41.50. Proceedings of a workshop held in May, 1986.

Interstellar Magnetic Fields: Observation and Theory, R. Beck and R. Gräve, editors, 1987, *Springer-Verlag New York.* 273 pages. ISBN 0-387-17751-5. $45.50. Proceedings of a workshop held in September, 1986.

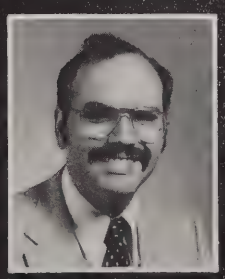
More than a solar eclipse ...

A galaxy of popular speakers will join the *Sky & Telescope*/Royal Cruise Line/ World of Oz voyage into the Moon's shadow next March 18th. Here's a preview of some of the featured topics.

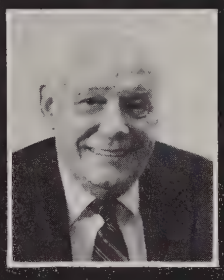
Jay Anderson. Next to the captain, Jay will be the most important person aboard our ship. His meteorological expertise will put the *Golden Odyssey* in the best location for prospects of clear skies. In addition to regular weather briefings, Jay will speak on weather prospects for future solar eclipses. In another lecture he will look at images from weather satellites and ask, "Is there life on Earth?" Finally, Jay will compare weather patterns and surface features on Earth and Mars.



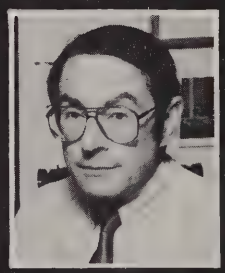
Michael Collins. Recalling his experiences as command-module pilot of Apollo 11 — the first manned Moon lander — Mike fascinated fellow passengers during last year's Comet Halley cruise. So we've asked him to give a repeat performance. Mike will also speak about the future of the U. S. space program, why it doesn't seem to be working, and how it compares to the Soviet Union's program.



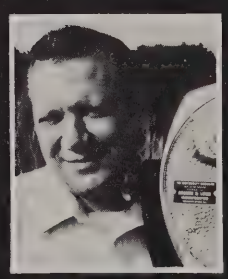
Stephen Edberg. Although widely known for his activities in coordinating the International Halley Watch, Steve has many other astronomical interests. In one of his lectures he will summarize what to look for during the total solar eclipse: "There's too much going on to see it all," he says. In another talk Steve will review what we know (and don't know) about the Sun. He will also discuss how solar activity influences the Earth.



Fred Hess. 1988 is the year of Mars; the Red Planet has its best apparition in nearly two decades. Fred will look at what we've done to explore Mars and what might be done in the future. Then, in his talk "Saros," he will show photographs of total solar eclipses that have occurred during the last 18 years. At night, of course, Fred will give his celebrated starlight talks on deck, where he will bring to life the constellations and legends of the southern sky.



Leon Jaroff. As science editor of *Time* magazine, Leon was responsible for orchestrating its dynamite coverage (March 23rd) of this year's famous supernova. He'll review what we've learned about that exploded star and will also bring us up to date on how comets may have killed the dinosaurs.



Robert Little. To help you get pictures of a lifetime, Bob will hold a detailed eclipse-photography workshop. And, as for all talks, there will be ample time afterward for you to ask questions. Later in the cruise Bob will present his thoughts on all kinds of astrophotography activities.

Limited space remains aboard the *Golden Odyssey*. Enjoy the March 18, 1988, total solar eclipse in comfort and safety by reserving your stateroom now.

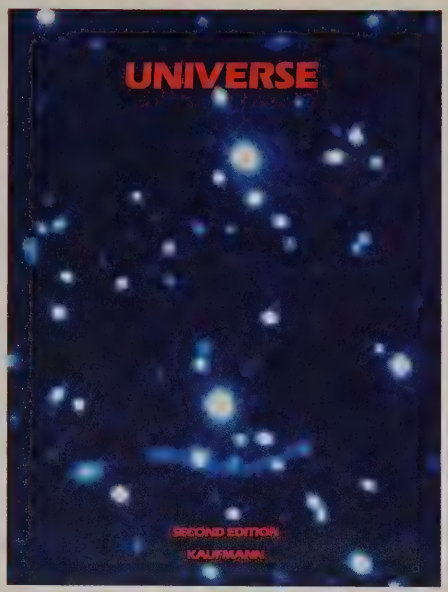
Call (NY) 212-826-0855; (Outside NY) 800-248-0234 • World of Oz, Ltd., 20 E. 49th St., New York, NY 10017

Sky & Telescope

Royal Cruise Line

The World of OZ

Just Published



UNIVERSE SECOND EDITION

William J. Kaufmann, III SAN DIEGO STATE UNIVERSITY

When the first edition of Bill Kaufmann's UNIVERSE was published in 1984, it was an immediate success:

"This is the first text to have color in actual text photos; not in a center insert or inserts scattered throughout the book."
—Robert Allen, UNIVERSITY OF WISCONSIN, LA CROSSE

"This is perhaps the clearest and most complete treatment of modern astronomy at an introductory level that I have seen."
—Roger Freedman, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

"It is the most up-to-date astronomy text that I have seen and has exceptionally clear and concise explanations."
—Hal Jandorf, MOORPARK COLLEGE

"Excellent—well written and superbly illustrated. Thoroughly up-to-date. Should quickly become the standard by which others are judged."
—Dan Purrington, TULANE UNIVERSITY

NEW IN THE SECOND EDITION:

- Carefully refined and sharpened narrative
- Overall updating throughout, including absolutely current coverage of Comet Halley and Uranus
- New full-color photos and diagrams
- New guest essays by such noted scientists as Frank Drake, Riccardo Giacconi, and Owen Gingerich

And the Second Edition comes complete with a Slide Set (60 color illustrations from the text) and an IBM PC-compatible Computerized Test Bank—both free with adoption of 100 copies of the text purchased from the publisher.

Available in November
688 pages (approx.);
480 illustrations,
189 in full color
Cloth ISBN 0-7167-1927-4

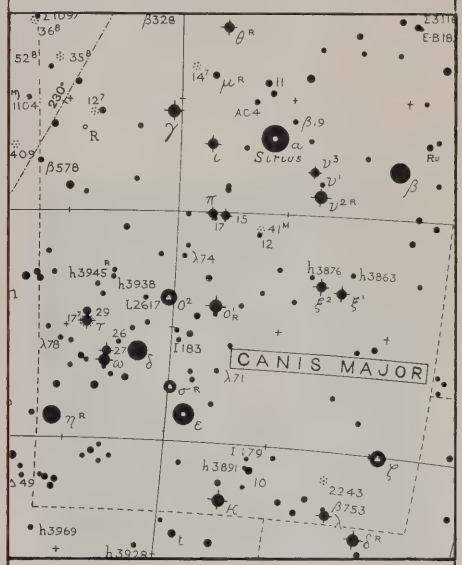
If you would like a copy to consider for adoption, send your request on school letterhead stating course name, enrollment, and present text in use to:

W.H. FREEMAN AND COMPANY
Attn: D. Walker
41 Madison Avenue, New York, NY 10010

The World's Most Famous Star Atlas!

NORTON'S STAR ATLAS AND REFERENCE HANDBOOK

Edited by Gilbert E. Satterthwaite, Patrick Moore, and Robert G. Inglis



A small section of one map, showing the constellation Canis Major. Reproduced slightly smaller than actual size.

Demand by amateur astronomers has kept *Norton's Star Atlas* in print for four generations. The reason? *Norton's* was designed exceptionally well.

Most of the sky is shown on six big sectors, all the way from declination +60° to −60°, presenting the stars by season around the year. The north and south polar regions are each covered on additional single charts. Stars are plotted to magnitude 6⅓, the naked-eye limit. Double stars for small telescopes are plotted even if somewhat fainter. Deep-sky objects are shown with their Herschel designations, which provide a key to what they look like. (A separate table converts these to NGC numbers.) Red stars are labeled as such.

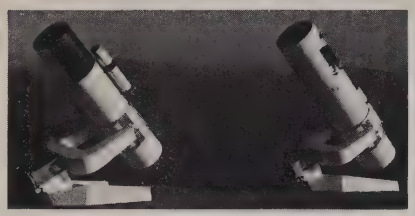
Interesting objects on each chart are listed and described — over 700 in all. There are 116 pages of reference material about all aspects of practical amateur astronomy. The book also contains Moon and Mars maps.

Order 89005 *NORTON'S* . . . **$29.95**

Mass. residents add 5% sales tax. Foreign add 15% for postage. All foreign payments must be in U. S. funds drawn on a U. S. bank or by International Money Order. **Use the order form in the center of this issue, or write to:**

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, MA 02238-9102

TECTRON TELESCOPES



LIGHTWEIGHT 16″ & 20″ NEWTONIANS
Rigid fork mountings are clock-driven. Primary mirrors are 2″ thick, ¼₀th-wave. Complete 20″ telescopes from $8,195.00. Precision-machined assemblies are available for ATM's.

FREE BROCHURE (813) 758-9890
2021 Whitfield Park Ave.
Sarasota, FL 34243

LOVE AT FIRST SIGHT

The 92mm f/7 BRANDON Apochromat has a hand-corrected Christen triplet lens which provides color-free pinpoint star images against an incredibly pure black sky background.

To find out how you may acquire what many are calling the best portable telescope ever made, please phone or write today.

VERNONscope & Co.
Candor, New York 13743
607-659-7000

Now Available!

ANNUAL PUBLICATIONS

Why wait until the year begins? Assure yourself of the earliest possible delivery of any of these great annual guides to the sky!

1988 Sky-Gazer's Almanac Wall Chart

By request of teachers and observers everywhere, Sky Publishing has prepared a special large wall-chart version of our famous Sky-Gazer's Almanac, which appears yearly in the center of the January *Sky & Telescope*. In a 23″ x 28″ black-and-white format, the wall chart vividly illustrates on a larger, clearer scale the movements of the Sun, Moon, and planets. You can easily locate all rising and setting times, plus numerous special events (conjunctions, oppositions, meteor showers...) that are plotted against its daily and hourly axes. With its ample space and black lines on special mat-finished paper, notes can be made right on the chart. It comes complete with a descriptive fact sheet explaining its use.

Get a great overview of the entire astronomical year! (Note: The Sky-Gazer's Almanac 1988 Wall Chart is available *now*.)

Your order shipped in a heavy mailing tube, is postpaid in the United States.

Order S1000 *SKY-GAZER'S ALMANAC* ...**$4.95**

Special! Three almanacs sent to the same address ...**$9.95**

Wonders of the Universe 1988 Calendar

Make your wall come alive with explosive imagery! Send for the 1988 *Wonders of the Universe Calendar*. In 12 colorful high-resolution photographs, this beautiful calendar captures the dynamic character of modern astronomy. Pictured are intriguing deep-sky objects and outstanding views of our solar system, as well as a host of astronomical facilities. Important sky happenings and historic moments in space exploration highlight the days of the year. This beautiful wall calendar extends a full 11¼ by 22½ inches, giving ample space for writing notes. A superb gift idea!

Order S0005 *WONDERS* ...**$8.45**

Observer's Handbook 1988
Royal Astronomical Society of Canada

This respected yearbook, now in its 80th year, can be purchased directly from Sky Publishing Corp. The extensive daily Sun, Moon, and planet listings are augmented by numerous tables that are updated with the best current data. Among the subjects covered are planetary satellites, asteroids, occultations, brightest and nearest stars, doubles, variables, deep-sky objects, and meteor showers. *184 pages (approx.), softbound.*

Order H1988 *HANDBOOK* ...**$10.00**

The Astronomical Companion
Guy Ottewell

This amateur guide and reference book provides a general background on a wide range of astronomical subjects. It is loaded with facts, figures, and lucid explanations. The 11-by-17-inch format allows full scope for Ottewell's many detailed, panoramic diagrams. *73 pages, softbound.*

Order 56010 *COMPANION* ...**$12.00**

Astronomical Calendar 1988
Guy Ottewell

Ottewell's legendary *Astronomical Calendar* is a unique yearbook that uses highly imaginative diagrams and graphics to make the sky come alive. In addition to detailed day-by-day summaries of "what's up," there is much material that explains why the celestial events occur. For anyone who wants to understand and appreciate the sky better, this is indispensable.

Order C1988 *ASTRO CAL* ...**$12.00**

Sky-Gazer's Almanac 1988

Our famous *Sky-Gazer's Almanac* for 1988 is available in a special 8-page booklet. This colorful version of our once-a-year sky guide (printed in the January issue) gives the daily rise and set times of the Sun, Moon, and planets plus loads of other useful information. Also included is our Lunar Map! Accompanying the chart are four pages of descriptive text. Available *now*!

Order S2000 *SKY GUIDE* ...**$1.00; 2 for $1.50; 3 for $2.00**

Mass. residents add 5% sales tax. Foreign add 15% for postage. All payments must be in U. S. funds drawn on a U. S. bank, or by International Money Order. **Use the order form in the center of this issue, or write to:**

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, MA 02238-9102

Take any 1 of 4 sets for only $4.95

when you join

The Astronomy Book Club

Please accept my application for trial membership and send me the set that I have indicated below, billing me only $4.95, plus shipping and handling. I agree to purchase at least three additional Selections or Alternates over the next 12 months. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three additional books. A shipping and handling charge is added to all shipments.

Check which one you want:

- ☐ Basic Astronomy Library (00838)
- ☐ Amateur Astronomer's Library (00847)
- ☐ The Webb Society Deep Sky Observer's Handbook (00806)
- ☐ Burnham's Celestial Handbook (36978)

No-Risk Guarantee: If I am not satisfied—for any reason—I may return my introductory set within 10 days. My membership will be canceled, and I will owe nothing.

Name _____

Address _____ Apt. _____

City _____

State _____ Zip _____

(Books purchased for professional purposes may be a tax-deductible expense. Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)

L-BV8 Sky & Telescope 11/87

Take any 1 of 4 sets for only $4.95

when you join

The Astronomy Book Club

Please accept my application for trial membership and send me the set that I have indicated below, billing me only $4.95, plus shipping and handling. I agree to purchase at least three additional Selections or Alternates over the next 12 months. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three additional books. A shipping and handling charge is added to all shipments.

Check which one you want:

- ☐ Basic Astronomy Library (00838)
- ☐ Amateur Astronomer's Library (00847)
- ☐ The Webb Society Deep Sky Observer's Handbook (00806)
- ☐ Burnham's Celestial Handbook (36978)

No-Risk Guarantee: If I am not satisfied—for any reason—I may return my introductory set within 10 days. My membership will be canceled, and I will owe nothing.

Name _____

Address _____ Apt. _____

City _____

State _____ Zip _____

(Books purchased for professional purposes may be a tax-deductible expense. Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)

L-BV8 Sky & Telescope 11/87

Take any 1 of 4 sets
for only $4.95!

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 230 RIVERSIDE, N J

POSTAGE WILL BE PAID BY ADDRESSEE

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

The Astronomy Book Club
Riverside, New Jersey 08075-9889

Take any 1 of 4 sets
for only $4.95!

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 230 RIVERSIDE, N J

POSTAGE WILL BE PAID BY ADDRESSEE

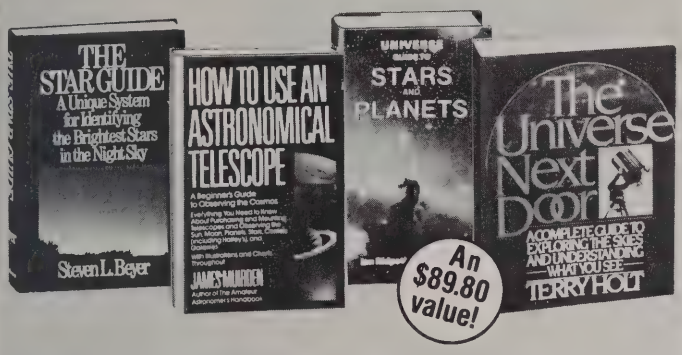
NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

The Astronomy Book Club
Riverside, New Jersey 08075-9889

Take one of these four sets
—valued to $108.65—
for only $4.95 as your introduction to the Astronomy Book Club

You simply agree to buy 3 more books—at handsome discounts—within the next 12 months.

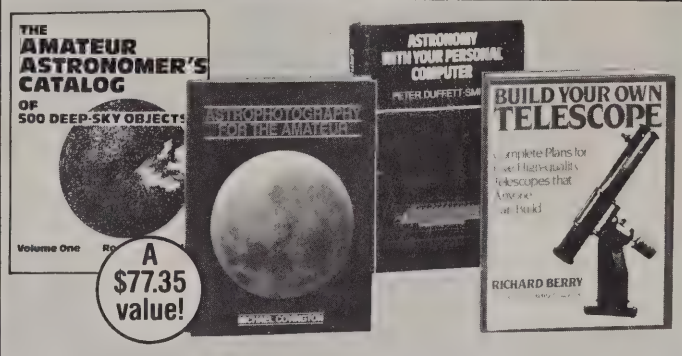
THE BASIC ASTRONOMY SET


THE STAR GUIDE
A Unique System for Identifying the Brightest Stars in the Night Sky
Steven L. Beyer
HOW TO USE AN ASTRONOMICAL TELESCOPE
A Beginner's Guide to Observing the Cosmos
JAMES MUIRDEN
STARS AND PLANETS
The Universe Next Door
A COMPLETE GUIDE TO EXPLORING THE SKIES AND UNDERSTANDING WHAT YOU SEE
TERRY HOLT
An $89.80 value!

Four volumes packed with thousands of tools, tips, and trends that make you a better astronomer...

- proven tips on using your telescope to observe everything from the moon, planets, and comets, to double and multiple stars, nebulae, and galaxies
- over 100 maps help you identify constellations using binoculars
- a new, easy-to-use system for identifying the brightest stars in the night sky

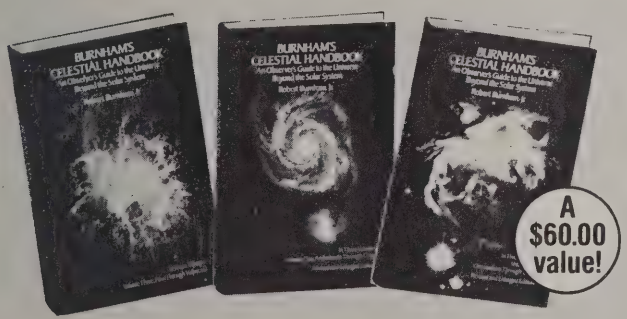
THE AMATEUR ASTRONOMER'S LIBRARY



Four "can-do" volumes for the astronomer who has a professional's desire ... but not the equipment

- take clear pictures of objects you thought only professionals could photograph
- turn your pc into an astronomical tool
- actual plans for building five high-quality telescopes
- identify 500 New General Catalog deep-sky objects with a small or medium-sized telescope.

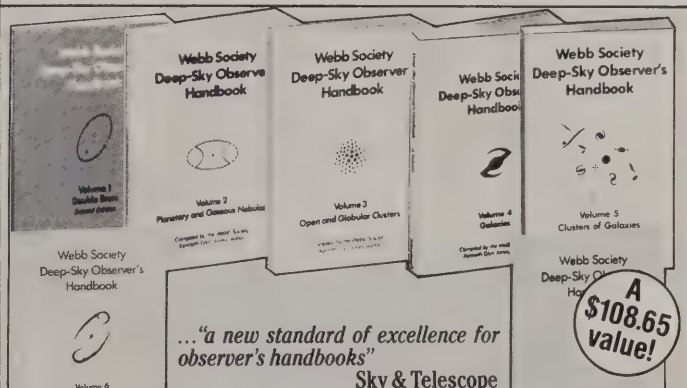
BURNHAM'S CELESTIAL HANDBOOK



"The most significant event in ... deep-sky publishing," wrote Astronomy Magazine *of this three-volume set, "a wealth of information ... a classic," wrote* Sky & Telescope ...

- more than 7,000 deep-sky objects
- detailed descriptions of the most important stars, nebulae, and galaxies in each constellation
- over 650 photographs, finder charts, graphs, and diagrams

WEBB SOCIETY DEEP-SKY OBSERVER'S HANDBOOK



...."a new standard of excellence for observer's handbooks"
Sky & Telescope

seven volumes, more than 1,700 detailed deep-sky entries

- hundreds of detailed drawings, diagrams, and photographs depicting formations as you would see them
- ideal for measuring star magnitude, spectra, parallax, arc seconds, and more.

About The Astronomy Book Club

The Astronomy Book Club is operated exclusively for astronomy enthusiasts. It offers only the finest astronomy books available and offers members the opportunity to purchase them conveniently and inexpensively.

MEMBERSHIP BENEFITS • In addition to getting the set of your choice for only $4.95 when you join, you keep saving substantially on the books you buy. • Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings of up to 65% off the publishers' prices. • At 3–4 week intervals (16 times per year), you will receive the Astronomy Book Club News, describing the coming Main Selection and Alternate Selections, together with a dated reply card. • If you want the Main Selection, do nothing, and it will be sent to you automatically. • If you prefer another selection, or no book at all, simply indicate your choice on the card and return it by the date specified. • You will have at least 10 days to decide. If, because of late mail delivery of the News, you should receive a book you do not want, we guarantee return postage.

If reply card is missing, please write to the Astronomy Book Club, Dept. L-BV8, Riverside, NJ, 08075, for membership information and an application.

Sky & Telescope 11/87

FREE CATALOGS

ASTRONOMY
EDUCATORS
AND RESEARCHERS

MORE THAN 5,000 EDUCATORS, RESEARCHERS, LECTURERS, ETC., AROUND THE WORLD USE OUR:

- SLIDES
- VIDEOCASSETTES
- MOVIES
- GLOBES
- PORTABLE SCHOOL PLANETARIUMS
- TELESCOPES
- MICROCOMPUTER SOFTWARE
- PHYSICS LAB APPARATUS
- TEACHING MODULES
- CHARTS AND MAPS
- POSTERS AND LASERPRINTS
- BOOKS AND MANUALS

Write for FREE catalogs –

Educators: FREE on school letterhead
Others: U.S.A. & Canada send $2.00. Overseas send U.S. $4.00 for prompt airmailing

MMI SPACE SCIENCE CORPORATION, Dept. ST-85
2950 Wyman Parkway
Box 19907, Baltimore, MD 21211
Tel: (301) 366-1222 • Telex: 6849070 MMI UW

FREE CATALOGS

FREE CATALOGS

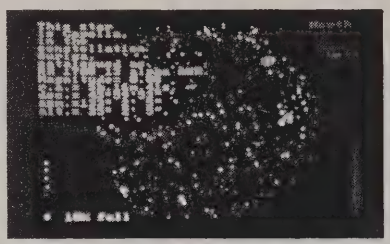
FREE CATALOGS

DEMO $5.00

OBSERVE intelligently with P.C. Planetarium

and your IBM PC or compatible:128K, (256K for Tandy), med. res. graphics, dot-matrix printer.

* On the screen, your map is interactive: it points out and gives accurate local coordinates for each object (including ones whose r.a. and dec. you provide); and it highlights each constellation.



* On paper, the high-resolution printed map is an invaluable tool for your observing session, or an impressive gift for a friend.

PLEASE CHARGE ME

☐ **$5.00** for demo (applicable to the price of **P.C. PLANETARIUM).**

☐ **$52** for **P.C. PLANETARIUM.**

☐ **$67** for **P.C. PLANETARIUM** and a hand-documented listing of the **BASIC** source code.

Name _____

Address _____

City/State/Zip _____

Charge my ☐ AE, ☐ MC, ☐ Visa

No. _____

Exp. Date _____ (or enclose check)

LIGHT Software
1850 Union Street, #252
San Francisco, CA 94123
(415) 493-3631

WE MAKE QUALITY ASTRONOMICAL SPECTROGRAPHS

We offer simple and efficient spectrographs for smaller telescopes, from $695.00, that will give serious students an excellent introduction to astronomical spectroscopy.

Our research spectrographs are custom manufactured to meet the exacting requirements of the professional astronomer. Requests for proposals answered promptly.

Send inquiries to:

Dr. Ron Hilliard
OPTOMECHANICS RESEARCH, INC.
P. O. Box 87, Vail, AZ 85641
(602) 647-3332

6″ F-13.3 FOLDED BRANDT REFRACTOR TUBE ASSEMBLY

SPECIAL SALE PRICE $1895.
($700 Saving)

IMPORTANT: We will limit production of this instrument to only 30 units. Other obligations prohibit us from manufacturing more at this time. Order early. We reserve the right to refund orders if they exceed our production limit.

This offer expires January 31, 1988.

With 6″ aperture, Zerodur® flats, optics by BRANDT and serial numbers, this instrument is sure to be a collector's item.

Own a classic, at a sale price!

Consider moving up to our line of instruments.

For more information, write to:

LIMITED EDITION · SPECIAL OFFER

The name R. E. BRANDT has long been honored as the manufacturer of fine refractor telescopes to 14 inches aperture. For over 25 years, professionals and amateurs worldwide have been observing with precision instruments made by the master optician.

In celebration of this, we at PASLOW OPTICAL present this limited edition tube assembly. By today's standards, classical refractors are bulky and Schmidt-Cassegrain instruments are hindered by secondary obstruction. Neither telescope offers a combination of superior resolution and portability.

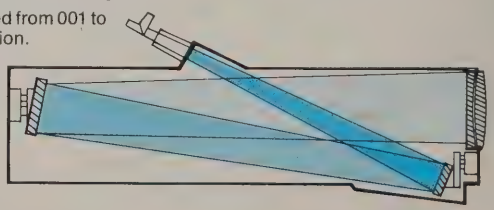
Now consider the advantages of the BRANDT FOLDED REFRACTOR.

By introducing two optical flat mirrors at strategic positions, we have successfully folded the light path from the objective lens into a shorter, cleaner design. Favorably, image quality and resolution are excellent, with no appreciable light loss by the reflecting surfaces. Mirrors are tilted and thus eliminate the need for central obstruction, as with Newtonian and Schmidt-Cassegrain telescopes.

The result is a tremendously powerful instrument, ideally suited for the moon, planets and double stars, and because of the lack of central obstruction, our system performs like reflector telescopes of much larger size. Incredibly, our 6″ F-13.3 FOLDED BRANDT REFRACTOR bends 79.8 inches of equivalent focal length into a tube a mere 33″ long!

Each LIMITED EDITION *FIBERGLASS* TUBE ASSEMBLY includes:
6″ F-13.3 BRANDT ACHROMATIC DOUBLET

- Computer designed to eliminate excessive color in the visual range (5100 to 6500Å). Excellent resolution and no coma or spherical aberration over a large ½° field.
- Two precision Zerodur® low expansion optical flats, with high 98% reflection coatings.
- 1¼″ rack-and-pinion focuser, with star diagonal.
- Brass plaque serial numbered from 001 to 030, and instrument description.



• *Simulated light path of folded Brandt refractor tube assembly*

P&SLOW OPTICAL CO.

5330 Blossom Road, Pittsburgh, PA 15236 (412) 653-7600 8:30–4:30 E.S.T. Mon.–Fri.

37° 31′ 33″ N

77° 35′ 41″ W

ATLASES AND CATALOGUES

- ☐ **Uranometria 2000.0, Vol. 1 Northern Hemisphere to −6** Tirion 39.95
- ☐ **Sarna Deep Sky Atlas** Sarna 29.95
- ☐ **Handbook of Constellations** 5th ed. Vehrenberg 34.95
- ☐ **Atlas of Deep Sky Splendors** Vehrenberg 39.95
- ☐ **Norton's Star Atlas** 29.95
- ☐ **Atlas of Galactic Nebulae, Part 1** Neckel/Vehrenberg 68.00
- ☐ **Yale Bright Star Catalogue** Hoffleit 45.00
- ☐ **Supplement to Yale Bright Star Cat.** 18.00
- ☐ **Sky Atlas 2000.0 Deluxe** Tirion 34.95
- ☐ **Field Edition** (Unbound-white stars) 15.95
- ☐ **Sky Catalogue 2000.0**
  - **Vol. 1.** Stars to Mag. 8 ..... 29.95
  - **Vol. 2.** Dbl., Var. Stars and Non-Stel Objs. 29.95
- ☐ **Mag 6 Atlas** 16.95
- ☐ **Hubble Atlas of Galaxies — Cloth** 29.00
- ☐ **Messier Album** Mallas/Kreimer 16.95
- ☐ **Atlas of Hist. Eclipse Maps, East Asia** Stephenson 79.50
- ☐ **Southern Galaxy Catalogue** Corwin 21.00
- ☐ **Nearby Galaxies Atlas** Tully/Fisher 59.50
- ☐ **Atlas Designed to Illus. Geography of Heavens** Burritt 22.75
- ☐ **Appar. Places of Fund. Stars 1987** 40.00
- ☐ **Cape Photographic Durchmusterung Atlas** Rappaport 450.00
- ☐ **Atlas Borealis** Becvar 49.95
- ☐ **Atlas Australis** Becvar 49.95
- ☐ **Atlas of Andromeda Galaxy** Hodge 60.00
- ☐ **Galaxies** Ferris 16.95
- ☐ **Small Magellanic Clouds** Hodge/Wright 65.00
- ☐ **Cat. of Star Clusters & Assoc.** w/Sup. 115.00
- ☐ **Syst. for Open Star Clusters & The Galaxy Atlas of Open Star Clusters** Alter 72.50
- ☐ **Catalogue of Cometary Orbits** Marsden 12.00
- ☐ **Ariz.—NASA Atlas of Infrared Solar Spectrum** 18.95
- ☐ **Rev. Shapley-Ames Cat.** Sandage/Tammann 30.00
- ☐ **SAO Star Catalogue** 4 vol. 60.00
- ☐ **Reference Catalogue of Bright Galaxies** 35.00

REFERENCE

- ☐ **Astronomical Almanac 1988** USN 21.00
- ☐ **Astronomical Almanac 1987** USN 18.00
- ☐ **Almanac for Computers 1987** USN 4.75
- ☐ **Almanac for Computers 1986** USN 3.50
- ☐ **Floppy Almanac for IBM-PC 1988** U.S. Naval Observatory 20.00
- ☐ **Floppy Almanac for IBM-PC 1987** U.S. Naval Observatory 20.00
- ☐ **Astrophysical Quantities** Allen 65.00
- ☐ **Calendar Conversions by Julian Day Number** Harvey 14.00
- ☐ **Planetary and Lunar Coord. 1984-2000** 15.00
- ☐ **Ephemeris of the Moon 1800-2000** MacCraig 7.75
- ☐ **200 Year Ephemeris 1800-2000** MacCraig 15.00
- ☐ **Astro. Tables of Sun, Moon & Planets** 19.95

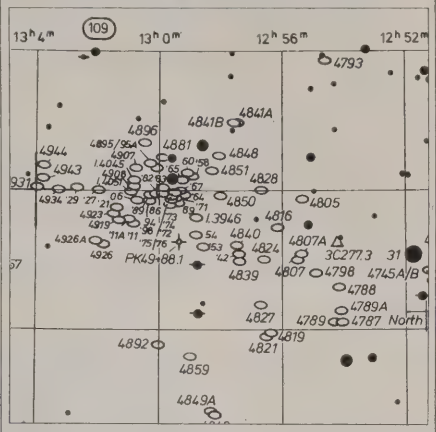
HANDBOOKS

- **Webb Soc. Deep-Sky Observer's Handbook**
  - ☐ **Vol. 1.** Double Stars 2nd ed. 14.95
  - ☐ **Vol. 2.** Planetary & Gaseous Nebulae 11.95
  - ☐ **Vol. 3.** Open & Globular Clusters 15.95
  - ☐ **Vol. 4.** Galaxies 17.95
  - ☐ **Vol. 5.** Clusters of Galaxies 17.95
  - ☐ **Vol. 6.** Anonymous Galaxies 12.95
  - ☐ **Vol. 7.** Southern Hemisphere 16.95
- **Burnham's Celestial Handbook**
  - ☐ **Vol. 1.** Andromeda thru Cetus 11.95
  - ☐ **Vol. 2.** Chamaeleon thru Orion 11.95
  - ☐ **Vol. 3.** Pavo thru Vulpecula 12.95
- ☐ **How to Use an Astronomical Telescope** Muirden 21.95
- ☐ **Amateur Astronomers Handbook** 4th ed. Sidgwick 11.95
- ☐ **Field Guide to Stars & Planets** Menzel/Pasachoff 12.95
- ☐ **Astronomical Objects for Southern Telescopes** Hartung 17.95
- ☐ **The Light-Hearted Astronomer** Fulton 6.95
- ☐ **Wonders of the Sky** Schaaf 7.95
- ☐ **Exploring the Moon** Cherrington 11.95
- ☐ **Observers Handbook 1987** RASC 9.00
- ☐ **Astronomy: A Handbook** Roth 24.95
- ☐ **Obs Astro for Amateurs** Sidwick, 4th ed 9.95
- ☐ **Proj & Demo in Astro** Tattersfield 44.95
- ☐ **Observing Visual Double Stars** Couteau 9.95

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE.
Foreign Customers—shipping charges extra; write for free Proforma invoice detailing costs.

☐ ☐ VISA ☐ SUB TOTAL $ _____
HANDLING 1.00
MC INTERBANK NO | CARD EXPIRES MO YR
VA: + 4½% Tax _____
CHARGE CARD NUMBER TOTAL $ _____
CARD HOLDER NAME (PLEASE PRINT)
CARD HOLDER SIGNATURE
NAME
ADDRESS
CITY STATE ZIP

A CLUSTER OF GALAXIES FROM URANOMETRIA 2000.0



The above full sized segment from Uranometria 2000.0's Chart 149 plots and labels over 70 galaxies near the North Galactic Pole in the constellation Coma Berenices. In this small segment of the sky you can spend hours exploring this gathering of galaxies and you don t need a computer driven telescope costing thousands of dollars to find them! Because URANOMETRIA 2000.0's limiting magnitude is 9.5 you can star hop into area, then switch to high power galaxy hopping! Don't have a telescope? Most "night" binoculars reach magnitude 9.5. The hundreds of open star clusters (and much, much more) in this atlas make binocular observing a joy without the hassle of setting up a telescope. Volume 1—The Northern Hemisphere to −6° is available now. Volume 2—The Southern Hemisphere to +6° will be available mid-1988. Together they plot over 330,000 stars and 10,300 deep sky objects on 473 charts 9 by 11-inches. The Charts are durably bound in a hard back book. Each volume contains 259 charts with the 45 charts between ±6° included in both volumes.

☐ **URANOMETRIA 2000.0** Vol. 1, ... $39.95

RADIO ASTRONOMY

- ☐ **An Amat. Radio Telescope** Swenson 9.95
- ☐ **Invisible Universe Revealed** Verschuur 19.95
- ☐ **Early Years of Radio Astronomy** ed. Sullivan 39.50
- ☐ **Jodrell Bank Telescopes** Lovell 19.95
- ☐ **Interferometry & Synthesis in Radio Astronomy** Thompson 59.95
- ☐ **Radiotelescopes** Christiansen/Hogbom 59.50

MATHEMATICAL & POSITIONAL ASTRONOMY

- ☐ **Planetary Programs & Tables from −4000 to +2000** Bretagnon/Simon 19.95
- ☐ **Astro. Formulae for Calculators** Meeus 14.95
- ☐ **Low Precision Formulae for Planetary Positions** Van Flanders/Pulkkinen 5.00
- ☐ **Software for Photometric Astro.** Ghedini 26.95
- ☐ **Astronomical Methods & Calculations** Acker/Jaschek 34.95
- ☐ **Textbook on Spherical Astronomy** Smart 24.95
- ☐ **Astrophysical Formulae** Lang 39.95
- ☐ **Spherical Astronomy** Woolard/Clemence 69.00
- ☐ **Astrophysical Quantities** Allen 65.00
- ☐ **Orbits for Amat. W/Micro.** Tattersfield 31.95
- ☐ **Orbits for Amat. W/Micro., Vol. 2** Tattersfield 36.95
- ☐ **Spherical Astronomy** Green 29.95
- ☐ **Fundamental Formulas of Physics** Menzel 17.00
- ☐ **Practical Astro. With Your Calculator** 13.95
- ☐ **Fundamental Astrometry** Podobed 16.00
- ☐ **Vectorial Astrometry** Murray 69.00
- ☐ **Computational Spherical Astro.** Taff 44.95
- ☐ **Calculator Calculus** McCarty 19.95
- ☐ **Hdbk of Math. Functions** 19.95
- ☐ **Pocket Computer Prog. for Astro.** Klein 12.95
- ☐ **Microcomputers in Astro. Vol 1** Genet 23.95
- ☐ **Microcomputers in Astro. Vol 2** Genet 23.95

ASTROPHOTOGRAPHY

- ☐ **Astrophotography II** Martinez 18.95
- ☐ **Astrophotography—2nd ed.** Gordon 18.95
- ☐ **Colours of the Stars** Malin 32.50
- ☐ **LFK Astro. Exposure Guide** 4.50
- ☐ **Celestron Meets Home Video Recorder** 6.95
- ☐ **Astrophotography Basics** Kodak 0.50

HISTORY

- ☐ **Bedford Catalogue** Smyth 18.95
- ☐ **Big & Bright, History of McDonald Observatory** 9.95
- ☐ **Echoes of Ancient Skies** Krupp 19.95
- ☐ **Star Names, Lore & Meaning** Allen 7.95
- ☐ **Starlight Nights** Peltier 8.95

PHOTOMETRY

- ☐ **General Cat. of Photoelectric Mag. & Colors** 18.00
- ☐ **Supp. to Gen. Cat. of Photo. Mag. & Colors** 10.00
- ☐ **Astro. Photometry** Henden/Kaitchuck 29.95
- ☐ **UBVRIJKL Photometry of Bright Stars** 18.95
- ☐ **Software for Photometric Astro** Ghedini 26.95
- ☐ **Photoel. UBV Obs. of RR Lyrae Variable Stars** Johnson 4.50
- ☐ **Solar System Photometry Handbook** Genet 17.95
- ☐ **Cat. of Photoel. Mag & Colours of Visual Double & Multiple Systems** 30.00
- **Advances in Photoelectric Photometry**
  - ☐ **Vol. 1** Wolpert/Genet 23.95
  - ☐ **Vol. 2** Wolpert/Genet 23.95
- ☐ **Communications of IAPPP** Vol. 1-2, 4, 5, 6, 8, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27 each 4.50

TELESCOPES AND OPTICAL FABRICATION

- ☐ **How to Make a Telescope** 2nd ed Texereau 19.95
- ☐ **Advanced Telescope Making Techniques** Mackintosh
  - ☐ **Volume 1 — Optics** 19.95
  - ☐ **Volume 2 — Mechanical** 19.95
- ☐ **Microcomputer Control of Telescopes** Trueblood/Genet 19.95
- ☐ **Astronomical Observations, Optical Perspective** 29.95
- ☐ **Build Your Own Telescope** Barry 24.95
- ☐ **Adjust. & Testing of Tele. Objectives** 17.50
- ☐ **Tele. Making Mag.** Vols. 1-29 each 4.00
- ☐ **Riverside Tel. Makers Conf. 1986** 11.00
- **Amateur Telescope Making** Ingalls
  - ☐ **Vol. 2** 12.50
  - ☐ **Vol. 3** 12.50
- ☐ **All About Telescopes** Brown 12.95
- ☐ **How to Build Your Own Observatory** Berry 5.95
- ☐ **Stand. Hdbk. of Tel. Mkg.** Howard 15.95
- ☐ **Optics & Optical Instruments** Johnson 4.95
- ☐ **Optical Shop Testing** Malacara 55.95
- ☐ **Master Optical Techniques** DeVany 69.95
- ☐ **Optical Production Technology** Horne 109.00
- ☐ **Making Your Own Telescope** Thompson 9.95
- ☐ **Basic Optics & Optical Instruments** USN 9.95
- ☐ **The Telescope** Bell 6.95
- ☐ **History of the Telescope** King 9.95

OPTICAL THEORY AND DESIGN

- ☐ **Elements of Modern Optical Design** O'Shea 39.95
- ☐ **Lens Design Fundamentals** Kingslake 33.00
- ☐ **Optical System Design** Kingslake 32.00
- ☐ **Opt. Des/Ray-Tracing with Pkt Calc** 7.50
- ☐ **Optics, A Short Course for Eng. & Sci.** 39.95
- ☐ **Modern Optical Engineering** Smith 65.00
- ☐ **Optics** Hecht/Zajac 48.95
- ☐ **Hndbk of Optics** Opt. Soc. of America 98.00
- ☐ **Modern Optics** Brown 39.50

PLANETS—MOON—ASTEROIDS

- ☐ **Guide to Obs. Moon** B.A.A. 15.95
- ☐ **Planetary Rings** Greenberg/Brahic 35.00
- ☐ **Satellites** Burns/Matthews 55.00
- ☐ **Skylab Explores the Earth** NASA 18.00
- ☐ **Landsat Views the World** NASA 34.00
- ☐ **The Moon Our Sister Planet** Cadogan 34.50
- ☐ **Voyage to Jupiter** NASA 10.00
- ☐ **Viking Orbiter Views Mars** NASA 12.00
- ☐ **Planet Pluto** Whyte 28.00
- ☐ **Planet X and Pluto** Hoyt 10.95
- ☐ **Protostars and Planets II** Black/Matthews 45.00
- ☐ **Saturn** Gehrels 37.50
- ☐ **Moon Morphology** Schultz 63.00
- ☐ **Channels of Mars** Baker 45.00
- ☐ **Surface of Mars** Carr 24.95
- ☐ **Satellites of Jupiter** Morrison 49.50
- ☐ **Uranus and Outer Planets** Hunt 39.50
- ☐ **Moon's Acceler. & Its Physical Orig., Vol. 1** 40.00
- ☐ **Asteroids** Gehrels 35.00
- ☐ **Meeting with the Universe** NASA 14.00
- ☐ **Voyage of Mariner 10,** NASA 14.00
- ☐ **Images of Mars** NASA 4.50
- ☐ **Pioneer: First to Jup./Sat. & Beyond** 15.00
- ☐ **Planets, Stars & Nebulae** Gehrels 27.50
- ☐ **Venus** Hunten 49.95
- ☐ **Pioneer Venus** NASA 11.00
- ☐ **Viking Lander Atlas of Mars** NASA 22.00

For nearly 30 years the first edition of this book has been considered by many to be the best guide to making a Newtonian Telescope. The author takes you step-by-step through the process of grinding, polishing, testing, and installing your mirror in a tube on either an altazimuth or equatorial mount. This new edition with over 300 more pages now has entire chapters on making a Cassegrainian, optical windows, equatorial mounts, computer programs in generic BASIC for the reduction of Foucault test data and the design of two mirror telescopes — Cassegrainian, Dall-Kirkham, Pressmann-Carmichel, and Ritchey-Chretien. Also included are comprehensive bibliographies from *Sky and Telescopes* "Gleanings", *Scientific American* and *Telescope Making* magazines. *Astronomy* magazine's reviewer said "...the book has that same feeling of total mastery as the original...With this book, you have every chance of building what Texereau calls "a telescope that is optically beyond reproach".

☐ **How to Make a Telescope—2nd Edition,** Texereau 19.95

Willmann-Bell, Inc.
P.O. Box 35025
Richmond, Virginia 23235
United States of America

Monday–Saturday
9 A.M. – 9 P.M. E.S.T.
☎ (804) 320-7016

Publishers and Booksellers
Serving Astronomers Worldwide Since 1973

ASTROSOFT CO.

236 Watchung Avenue
North Plainfield, NJ 07060
(201) 949-8139 (days)

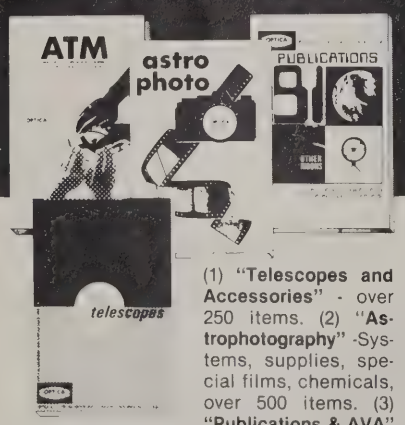
PRECISION PROGRAMS FOR YOUR HP67 or HP41 HAND CALCULATORS.

We have ASTROSOFT programs for:

* positions of planets, asteroids, and comets
* Sun and Moon rise & set
* lunar position & phases
* local apparent sidereal time
* ALL coordinate conversions
* precessional computations
* all M-object locations (az-alt)
* positions of Jupiter's satellites
* dates of holidays
* least-square fits
* astro-geometry

Send $1 for catalog. $1 refundable on first order.

4 OPTICA b/c CATALOGUES



(1) **"Telescopes and Accessories"** - over 250 items. (2) **"Astrophotography"** -Systems, supplies, special films, chemicals, over 500 items. (3) **"Publications & AVA"** - over 300 books, atlases, maps, slides, posters, recordings, globes, etc. (4) **"ATM"** - goods for the telescope maker. - over 400 items. Each catalog - $1.00; all four - $3.00. Also Receive: **FREE** Astronomical Events Calendar, a wealth of useful information, current discount price list and coupons. **FOREIGN** must add $3.50 for Airmail and send international postal money order or check drawn in U.S.$ on any U.S. bank. Astro equip. & supplies since 1939. Astro Aids, Celestron, Bushnell, Stellar Ventures, OPTICA b/c, Von Werner, B&L, etc.

OPTICA

OPTICA b/c Company
SALES/SERVICE DIVISION
4100 MacArthur Blvd., Oakland, Calif. 94619

OUR SUN HAS ALREADY STARTED ITS NEXT CYCLE OF SUNSPOT ACTIVITY.

DON'T BE LEFT BEHIND ... USE YOUR SCOPE DAY AND NIGHT ... NOT JUST HALF THE TIME! WE OFFER A LARGE SELECTION OF SOLAR SKREEN® SUN FILTERS.

Solar Skreen® Filters are the ONLY ones on the market that are recognized by a USA patent (#3,897,140). They make fine low-cost, highly prized Christmas gifts for your resident astronomers.

You can see clearly such surface features as sunspots, filaments, and granulation. Witness the many solar eclipses in the years to come.

The next eclipse is March 18, 1988.

ALL SOLAR SKREEN® SUN FILTERS:

- ARE *FULL* APERTURE
- ARE RECOMMENDED BY MEADE INSTRUMENT CORPORATION AND OTHERS
- MOUNT ON THE FRONT END OF SCOPES IN SECONDS
- COME COMPLETE WITH PHOTOGRAPHIC EXPOSURE DATA
- COME WITH INFORMATION ON SOLAR ECLIPSES VISIBLE IN NORTH AMERICA UNTIL THE YEAR 2030!

PARTIAL LIST OF MOUNTED FULL-APERTURE SOLAR SKREENS® AVAILABLE:

C60	$45	Meade 2.4″	$45	Odyssey	Call	Unmounted filters	
C80	$50	Meade 3.1″	$50	B&L 4000	$45	4″ Square	$30
C90	$45	Meade 97	$60	B&L 6000	$70	6″	$34
C5	$65	Meade 2045	$45	B&L 8000	$85	8″	$45
C8	$85	Meade 2080	$85	Renaissance	$60	10″	$61
C11	$125	Meade 2120	$120	Astroscan	$55	12″	$70
C14	$150	DS 10	$115	All other		14″	$90
C65	$45	DS 16	Call	scopes —	Call	20″	$110

Ask about our complete line of hydrogen-alpha filters for seeing solar prominences and flares — priced from $425.

Send for FREE Catalog or call us *TOLL FREE* 1-800-223-1063.
In N. J. call 201-232-1786.
WE ACCEPT VISA, MC, C.O.D. and personal checks.

Roger W. Tuthill, Inc.

11 Tanglewood Lane, Box 1086 ST, Mountainside, NJ 07092 USA

TELESCOPE SALE

Sale limited strictly to stock on hand on a first come/first serve basis
This ad MUST accompany your purchase for sale prices to be valid

NEW! Meade 2080/GEM and 2120/GEM

Meade 2120/GEM (left) and 2080/GEM (right)
The 2120/GEM is the most stable 10-14" Schmidt-Cassegrain available.

Celestron Super C-8, 8" f/10 Schmidt-Cassegrain **$1195**
C-8 wedge **$59**, Meade heavy-duty tripod for C-8 . **$295**
Meade Model 628C 6" f/8 **w/motor,** 2" focuser, 8X50mm finder, full equatorial mount & pier ($1500 list) . . . **$798**
Meade Model 645C, like 628C but 6" f/5 **w/motor** **$799**

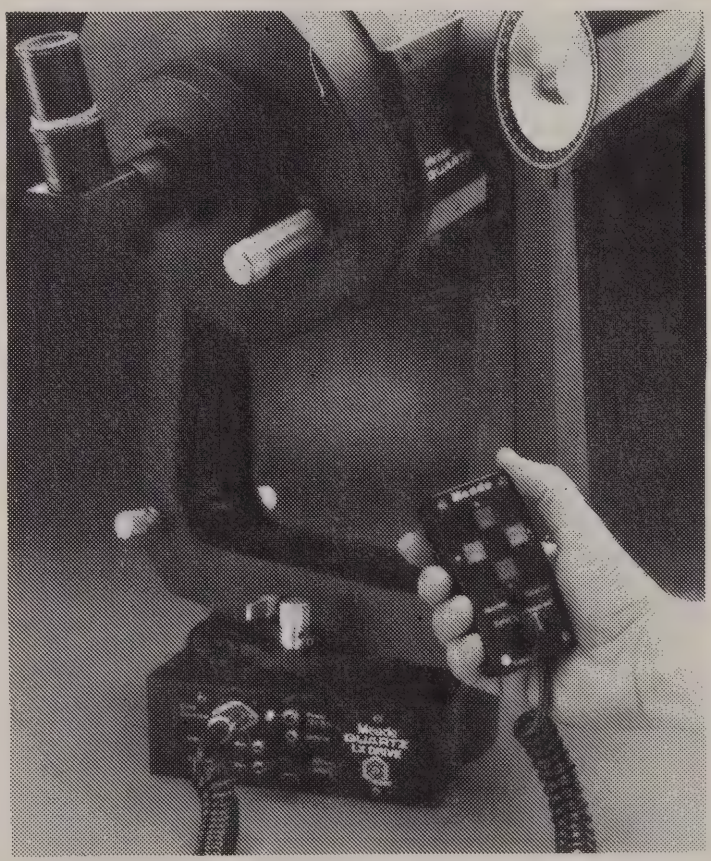
OTHER TELESCOPES ON SALE

Celestron Super Polaris SP-C8, 8" f/10 Schmidt-Cassegrain telescope on equatorial mount, adj. tripod . **$899**
Celestron Super Polaris SP-C8, 8" f/10 with high transmission coatings on equatorial mount ($1950 list) . . . **$998**
Celestron CO-114, 4½" f/9 reflector on complete equatorial mount & tripod ($750 list) **$395**
Celestron C80, 80mm f/11 refractor, full equat. mount **$595**
Celestron SP-C80, 80mm f/11 refrac., Super Polaris mt **$695**
Meade Model 6600 6" f/5 reflector on complete equatorial mount & tripod ($1300 list) **$595**
Meade Model 320 80mm f/11 refractor on full tripod, equatorial mount ($1100 list) **$598**
Celestron SP-C6, 6" f/5 on Super Polaris mount . . . **$695**
Celestron C-130, 5.1" f/5.5 on equatorial mount **$595**

LUMICON (415) 447-9570

2111 Research Drive, No. 5, Livermore, CA 94550
Store Hours: M-F 9 am - 5 pm, Sat. 11 am - 3 pm

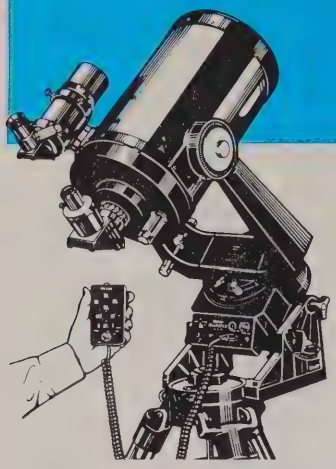
Meade 2080/GEM w/MCSO . . . $998
Celestron Super C-8 Starbrite $1195
Meade 2080/LX5 w/MCOG . . $1685
Meade 2120/GEM w/MCSO . . $1799
Meade 2120/LX3 w/MCSO . . . $1799
Meade 2120/LX5 w/MCOG . . . $1995



Meade 2080/LX3 complete 8" f/10 telescope system. Shown with optional #36 hand controller, add $99

Meade 2080/GEM 8" f/10 w/multi-coated silvered optics, hvy. duty equatorial mount, adjus. tripod ($2350 list) . . . **$998**
Meade 2080/LX5 8" f/10 w/multi-coated enhanced optics, 2" star diagonal, wedge & tripod ($3500 list) **$1685**
Meade 2120/GEM 10" f/10 with MCSO coatings, heavy duty equatorial mount, adjus. metal tripod, 8x50mm finder **$1799**
Meade 2120/LX3 w/MCSO, wdg., tripod ($5290 lst) **$1799**
Meade 2120/LX5 w/MCOG, all std. accessories . . **$1995**

MEADE



Meade 2080 LX-5 $1739
The Ultimate 8" Schmidt-Cassegrain.

Standard Features:
- AC/DC Quartz/Pulse drive
- Electronic Command Control
- 2x correction speed/8x scanning speed
- 2" diagonal mirror
- 9x60 polar illuminated viewfinder
- Super Plossl 26mm eyepiece
- Adjustable field tripod and wedge
- Lifetime warranty, and much more!

Meade 2120 LX-5 $2139
The Ultimate 10" Schmidt-Cassegrain! Includes standard LX-5 accessories and the improved Multi-Coated Optics Group.

Special!
All Meade
Series 4000 Eyepieces
40% OFF
suggested retail price!

Meade 6600 $629
Fast 6" f/5 equatorial reflector for bright viewing and short camera exposure times. With portable wooden tripod and much more!

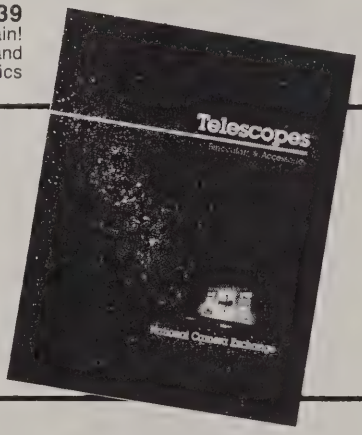
Meade 8800 $829

Meade 2045 $579

Meade DS 16A $1849
16" Deep space reflector for serious space viewing and astrophotography. Shipping truck freight collect.

Meade DS 10A $929
10" f/4.5 Deep space reflector.

Send $2
for the new
National Camera Exchange
Telescope Catalog!

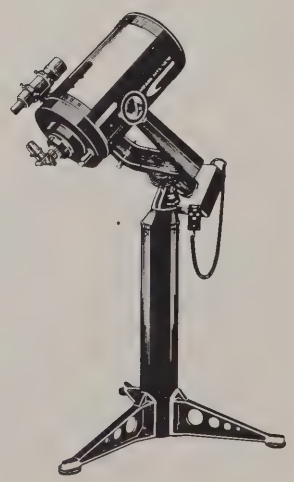


Meade 291 $299
Versatile 2.4" equatorial refractor for sharp observation of the moon, planets, and much more. Includes hardwood tripod, manual controls, 2 eyepieces, and lifetime warranty.

Meade 320 $579
Powerful 3" refractor for even more detailed viewing of planets, star clusters, and other objects. Includes hardwood tripod, manual controls, 2 eyepieces, and lifetime warranty.

Refractor Accessories
781 Motor Drive for 291 . . . . . $99
784 Motor Drive for 320 . . . . . $179
.965" Camera Adapter $19
1.25" Camera Adapter $35
Porro Prism $39
Telescope Case I for 291 . . . . . $39
Telescope Case II for 320 . . . . . $59

New! Meade MTS Catadioptrics!
Meade MTS-SC8 . . . . . $849
Meade MTS-SC10 . . . . . $1399
Meade MTS-SN6 . . . . . $549
Meade MTS-SN8 . . . . . $849
With Multi-Coated Optics Group (MCOG) . . . . . add $99



Meade MTS Accessories
788 Drive System $149
43 Drive Corrector $99
790 Drive System with control . . $439
Manual Declination Control $59
38M Declination Motor $99
109 Setting Circles $39
Viewfinders . . . . . starting at $49

Tele Vue Renaissance Telescope $1295
4" f/5.5 refractor with 4-element multi-coated objective. 5° Rich Field capability and high resolution. Old world craft with modern technology. Comes with one eyepiece. (Choose 7.4mm, 10.5mm, 13mm, 17mm, 21mm, or 26mm.)

Tele Vue Oracle 3 Telescope $695
A superb 3" refractor. Complete with 2" star diagonal, Plossl eyepiece, and case.

Used Telescopes!
Because of our large volume and exceptional trade-in policy, National Camera Exchange offers a great selection of quality used telescopes. Call or write for a current listing. Choose from Schmidt-Cassegrain, reflector, or refractor types....plus a large selection of used accessories. All with the National Camera Exchange warranty.

Swift Observational Binoculars $229
Exceptional contrast and clean image for sharp, high-power viewing. Choose 11x80 or 20x80 styles. Includes tripod adapter, case, and lifetime warranty.

Celestron C-11 with Starbright $4295
IN STOCK!
Define detail you've never seen before! This portable 11" Schmidt-Cassegrain yields a spectacular image both visually and photographically. Includes 8x50 polar finder, 18mm eyepiece, wedge, tripod, cases, and much more.

Accessories for Meade LX-5
#139 Declination Motor $89
Off-Axis Guider System $149
Tube Balance System $99
Camera Adapter $35
Piggyback mount $35
2" Guidescope with bracket (for 2120) $129
14mm Ultra Wide Eyepiece 2" . $209
8" Dew Shade $59
10" Dew Shade $99
8" Solar Filter $129
10" Solar Filter $149
Motofocus Electric Focuser $89

Meade 2045 $579

Meade 2045 LX3 $779

Meade 2120 LX-3 with Hand Control $1799
Trade up to an affordable, complete 10" telescope! Call now for details. Shipping freight collect.

Starter Telescopes
GREAT GIFT IDEAS!

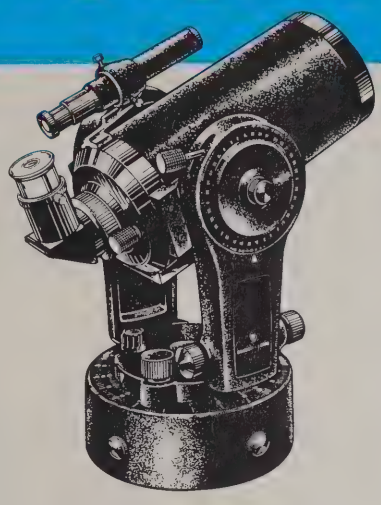
Meade 226 $129
A beginning refractor with professional quality! Features durable metal tube and focuser with 25mm and 9mm eyepieces, star diagonal, adjustable wood tripod, and altazimuth mount.

Meade 277 $149
A sharp and extremely bright portable refractor for all viewing activities. Includes heavy-duty table tripod, 25mm eyepiece, star diagonal, and compact case.

Meade 277 Kit $249
A complete 277, plus porro prism, 9mm eyepiece, camera adapter, and T-mount. Perfect for wildlife!

TO ORDER CALL TOLL-FREE 1-800-624-8107

BAUSCH & LOMB



Bausch & Lomb 4000 Professional $439
The professional 4" Schmidt-Cassegrain is great for astrophotography and sharp viewing! Features enhanced aluminum primary mirror, silvered secondary mirror, and fully multicoated optics. Includes 2 eyepieces, star diagonal, finderscope, clock drive, table tripod, 2X Barlow lens, 35mm camera adapter, case, and more.

4000 Pro with Wedge & Field Tripod $538

Bausch & Lomb 4000 Observatory $399
The affordable and versatile 4" Schmidt-Cassegrain telescope. Enjoy the stars, wildlife, photography, and more. Includes 2 eyepieces, star diagonal, finder, clock drive, table tripod, case, and complete self-instruction guide.

Bausch & Lomb 4000 with Wedge & Field Tripod $498

Bausch & Lomb 4000 Wedge & Tripod Special!
Buy the Bausch & Lomb 4000 Pro or 4000 Observatory, and
SAVE $100
on the full-sized wedge and tripod. A $199 list value, with purchase it's only...
$99
While supplies last.

Bausch & Lomb 8001 Professional $1095
The professional 8" Schmidt-Cassegrain system that's light years ahead of its time! Features enhanced aluminum primary mirror, silvered secondary mirror, and magnesium fluoride multicoated optics. Research-grade dual motor right ascension drive provides ultimate precision for all tracking applications. Includes 2 eyepieces, star diagonal, 8x50 finder, wedge, adjustable tripod, case, and much more.

Bausch & Lomb Eyepieces

50mm Ramsden	$39
50mm Hastings	$49
32mm Plossl	$59
18mm Symmetrical	$39
16.3mm Erfle	$59
12.7mm Symmetrical	$39
9mm Symmetrical	$39
7mm Symmetrical	$39
6mm Orthoscopic	$59
4mm Orthoscopic	$59
8.38.3-21mm Zoom Orthoscopic	$99
30mm Symmetrical	$39
Pro 35mm Plossl	$74
Pro 26mm Plossl	$74
Pro 17mm Plossl	$74
Pro 10mm Plossl	$74
Eyepiece adapter	$24

Bausch & Lomb RV 5+ Reflector $679
Newtonian telescope designed for the more advanced amateur astronomer. Features a fast f/5.5, 5.1" optical system, three eyepieces, tripod, accessory tray, equatorial mount with slow motion controls, built-in polar axis finderscope, and more. $1299 list.

Bausch & Lomb 4.5" Newtonian Reflector $349
The most aperture per dollar! Excellent for viewing the moon, planets, galaxies, nebulae and star clusters. Includes equatorial mount, tripod, and 3-0.96 eyepieces. $499 list.

New! Bausch & Lomb 3000 Spotting Scope $269
Compact Maksutov-Cassegrain 3.1" spotting scope/telephoto lens that offers versatility and portability...weighs less than 3.5 pounds. Includes star diagonal, 20mm and 12.5mm eyepieces, carrying case, and camera adapter.

Bausch & Lomb Deep Sky Observing Kit $189
Broaden your field of view and capture faint nebulae, galaxies, and star clusters. Includes RFT adapter assembly, 32mm Plossl, nebula filter, accessory case, star charts, and deep sky chart.

Bausch & Lomb Lunar/Planetary Observing Kit $169
Resolve and compare fine planetary and lunar details. Includes series 6 drop-in filter kit, 6mm ortho eyepiece, 12.7mm measuring reticle eyepiece, accessory case, and star charts.

Bausch & Lomb Advanced Observing Kit $139
Expand your viewing capabilities and advance to astrophotography. Includes polar alignment kit, camera adapter, T-mount, 2x Barlow, 10mm Pro Plossl eyepiece, accessory case, and star charts. Adaptable to most Schmidt-Cassegrain telescopes.

New Bausch & Lomb Astronomical Binoculars $299
The best in sight! Oversized BAK-4 prisms and full multicoating. Choose 11x80 or 20x80 model. Includes tripod adapter, caps, straps, and case.

New! Star Machine $29
Watch the stars inside your home "planetarium"! This compact home star projector comes complete with pointer, seasonal masks, instructional tape, and guide. Requires 2C and 2AA batteries, not included.

Bausch & Lomb Accessories

Star Diagonal	$24
Barlow lens 2X	$29
8x50 finder scope	$74
8x50 RA finder scope	$89
6x30 finder scope	$49
RFT adapter assembly	$99
f/5 focal reducer #1	$49
f/7.5 focal reducer #2	$49
Camera adapter 6000/8000	$24
Eyepiece projection tube	$24
Piggyback mount 8000	$39
Dynatracker	$169
Nebula filter	$59
Off-axis guider, complete	$149
Off-axis guider, T-section	$69
9mm Illuminated reticle	$89
Field tripod & wedge, 4"	$159
Camera adapter, 4"	$19
Porro prism	$49
Star diagonal 4000	$24
Solar filter 4000	$109
12.7mm measuring reticle eyepieces	$89
Counterweight set 6000/8000	$39
Spectral dispersion eyepieces	$99
Wedge 4000	$79
Polar Alignment kit	$29
Piggyback Mount 4000	$24
Astrophotography kit	$79
Optics cleaning kit	$24
T to C adapter	$29
Series 6 filter set	$59
Accessory case	$29

Visit our showroom!
In Golden Valley, Minnesota. We're open Monday through Friday, 9:00 a.m. until 8:00 p.m., Saturday 9:00 until 5:00, and Sunday 12:00 noon until 5:00 p.m.

VISA
MASTERCARD
DISCOVER CARD
are welcome!

30-day Money-back Guarantee
If you are not totally satisfied, return the equipment postage paid, packaged and in new condition for a full refund.

We Pay Freight!
Except where noted, National Camera will pay to ship your purchase within the continental USA. We use UPS wherever possible.

Trade-In, Trade-Up
We can take your old telescope or camera equipment on trade! Call for an estimate on your trade-in value.

Since 1914
National Camera Exchange
+Video

9300 Olson Memorial Highway, Golden Valley, Minnesota 55427
For information, call the telescope experts:
Brad Daniels, Jeff Marshall, or Dennis Quiggle at **(612) 546-6831.**

TO ORDER CALL TOLL-FREE 1-800-624-8107

FIBERGLASS TUBING AT LOW, LOW PRICES

6″ x 30″ long $15.95
7″ x 40″ long 29.95
9″ x 41″ long 29.95
10″ x 46″ long 49.95
12″ x 39″ long 59.95
14″ x 50″ long 79.95

Longer sizes available;
call evenings.

6″ f/5 or f/8 TELESCOPE KITS
Include: mirror, diagonal, 1¼″ focuser, tube (holes drilled), and mounting hardware.
6″ f/8 — $199.95
6″ f/5 — 239.95

EYEPIECES — Quality-Coated 1¼″
Ortho. 6mm, 9mm, 12.5mm, 18mm, 25mm $31.95
Kellner 20mm, 25mm 23.95
Erfle 32mm 49.95

VIEWFINDER 6 x 30mm w/brkt. . . . 28.95

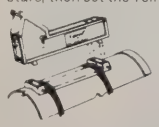
6″ *Mirror Kit* (inc. diag.) Alumz. . . . 99.95

Send for free price list.

ECONOMY TELESCOPE CO.
11721 EAST HILL DRIVE
CHESTERLAND, OH 44026
Call 216-729-4744 eves.

This picture shows the viewing end of a Telrad® attached to a telescope. The view seen through the window of the Telrad® is continuous with the sky around it, not magnified or upside-down. The three rings are lighted and appear to lie among the stars. The small ring outlines the Moon-sized area seen in the telescope. The large ring outlines the area seen in an optional finderscope.

To put a bright object in the telescope, look through the Telrad® and move the telescope until the rings are centered on the object. A faint object in the void between stars is first located on star charts. Note its position among the visible stars, then set the Telrad® rings on the same spot in the sky



The Telrad® is 8 inches long, weighs 11 ounces and mounts on any telescope without drilling holes. It unlocks from its base for separate storage.

Telrad® (2AA cells not included) $47.95
Cal. res. add 6% sales tax
Postage in U.S. $2.50

Steve Kufeld **(714) 847-8903**
7092 Betty Dr., Huntington Beach, CA 92647 U.S.A

EDWARD R. BYERS CO.

EDWARD R. BYERS CO., world-renowned for unsurpassed quality, is now offering a new PATENTED design of ultraprecision driving systems. It features 7½″, 9″, and 10″ worm gears with matching precision-ground stainless-steel worms, worm bearing housings, and synchronous motors — mounted as an integral unit and requiring only two screws to install. Worms are spring-loaded against gear teeth to eliminate backlash. Slip-clutches also available.

Call (619) 256-2377 or write to 29001 West Highway 58, Barstow, California 92311.

BETTER BUILT BY BYERS!

CANADA
Bausch & Lomb

Full storefront location. Western Canada's Largest Scope Dealer BINOCULARS, MAPS, BOOKS, FILMS, and TELESCOPES

Catalog — $4.00

QUASAR OPTICS
7220A Fairmount Dr. S.E.
Calgary, Alberta T2H 0X7
(403) 255-7633

VISA MasterCard

URANOMETRIA 2000.0
Volume 1 — The Northern Hemisphere to −6°

Announcing *Uranometria 2000.0:* The star atlas you have always dreamed of.

This gigantic work plots 330,000 stars to about magnitude 9½ plus 10,300 deep-sky objects, in two volumes. Volume I is now available. Its 259 charts, computer-plotted by Barry Rappaport and beautifully hand-finished by Wil Tirion, cover the sky from the north pole to declination −6°.

The charts are bound in sturdy book format 9 x 12 inches in size, as convenient for use at the telescope as at the desk. Also in this first volume is a 27-page treatise by George Lovi on the history of celestial cartography. (Lovi gives a detailed description of this new atlas in his article, "New Charts for the Deep Sky," in the June issue, page 611.)

Plumb the sky to whole new depths. Explore virgin territory that is just blank space on your old charts. Get whole new levels of performance from your telescope. And at an extraordinarily reasonable price!

Order S0017 *URANOMETRIA 1*...**$39.95**

Don't pay handling charges! Your order is shipped postpaid in the United States from Sky Publishing. *And don't wait!* Place your order now and we will ship your copy *immediately.*

Mass. residents add 5% sales tax. Foreign add 15% for postage. All payments from foreign countries must be in U. S. funds drawn on a U. S. bank, or by International Money Order. **Use the order form in the center of this issue, or write to:**

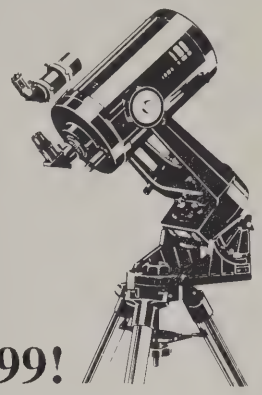
SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, MA 02238-9102

Special Purchase Meade Sale!

Meade

We made some special purchases on over $500,000.00 worth of the best telescopes Meade has to offer -- and we've priced them to save you as much as 2/3 off the list price! Some quantities are limited, however, and these prices are good only through December 31!

A $3220 2080/LX3 for $1369!



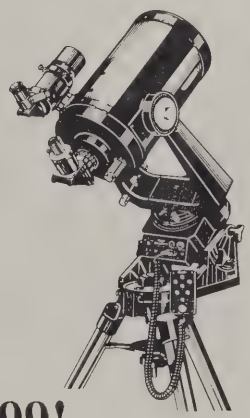
2080/LX3: We bought the 2080 inventories of several smaller dealers -- and the special price concessions we got make this the best value in 8" Schmidt-Cassegrain telescopes available today. Complete and ready to use the minute you get it, with all these features and accessories: 8" 2000mm f/10 optical tube; multi-coated silver optics for 23% higher light transmission and increased contrast; metal dust cover; 8 x 50mm right angle finderscope with illuminated polar axis reticle (includes battery); piggyback camera mount; 1 1/4" multicoated star diagonal; 1 1/4" visual back; 1 1/4" 26mm (77x) and 9.7mm (206x) Super Plossl eyepieces (some may have 1 1/4" 100x 20mm Research Erfle and 286x 7mm Research Ortho eyepieces); fork mount; LX precision worm gear drive; quartz-controlled sidereal rate electronic drive with power adapters and 25' extension cords for AC and 12 volt DC operation; manual slow motion controls and locks on both axes; r. a. and declination setting circles (r. a. circle power driven); power panel with input/output connections for optional hand control, map light, illuminated reticle eyepiece, and declination motor; equatorial wedge with compass, latitude scale, bubble level, micrometric azimuth control, deluxe latitude adjuster, and no-tool knob set; adjustable height tripod; audio instruction cassette; foam-lined carrying case with lock; lifetime warranty. *$3220 list.* Formerly $1699.

Brand-new first-line 2080/LX3, with MCSO, $1369!

A $5400 2120/LX3 for $1799!

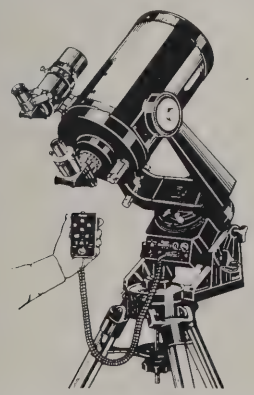
2120/LX3: Meade has made a special final production run on this superlative 10" Schmidt-Cassegrain telescope -- and only 250 people will be able to make the 10" telescope buy of a lifetime! You save 2/3! It's complete with all these features and accessories: 10" 2500mm f/10 optical tube; multi-coated silver optics for 23% higher light transmission and increased contrast; metal dust cover; 8 x 50mm right angle finder with illuminated polar axis reticle (includes battery); piggyback camera mount; 1 1/4" multicoated star diagonal; 1 1/4" visual back; 1 1/4" 22mm (113x) Super Plossl eyepiece; fork mount; LX precision worm gear drive; quartz-controlled sidereal rate electronic drive with power adapters and 25' extension cords for AC and 12 volt DC operation; bonus #36 hand control; manual slow motion controls and locks on both axes; r. a. and declination setting circles (r. a. circle power driven); power panel with input/output connections for optional map light, illuminated reticle eyepiece, and declination motor; equatorial wedge with compass, latitude scale, bubble level, micrometric azimuth control, deluxe latitude adjuster, and no-tool knob set; adjustable height tripod; audio instruction cassette; foam-lined carrying case with lock; lifetime warranty. *$5400 list.* Formerly a $2509 package. **2120/LX3, with MCSO and #36 hand control, $1799!**

A $3600 2080/LX5 for $1699!



2080/LX5: Here's a superb buy on a superb 8" telescope -- the state-of-the-art Meade 2080/LX5. You'll save better than 52% off the list price thanks to our large-volume buying power. This special extra-discount price is good from now through December 31 only, so don't miss this once-in-a-lifetime savings! Complete with all these features and accessories: 8" 2000mm f/10 optical tube; multi-coated optics group for 20% higher light transmission and increased contrast; metal dust cover; 9 x 60mm right angle finderscope with illuminated polar axis reticle (includes battery); 1/10th wave 2" multicoated star diagonal with 1 1/4" eyepiece adapter; 1 1/4" 26mm (77x) Super Plossl eyepiece; fork mount; LX precision worm gear drive; quartz-controlled sidereal rate electronic drive with power adapters and 25' extension cords for AC and 12 volt DC operation, plus battery pack for penlight battery operation away from all power sources; hand control with built-in map light, control for optional electric focuser, pushbutton controls for 2x drive corrector and 8x image scanning functions, switch-selected quartz/manual control and northern/southern hemisphere operation, variable rate control; manual slow motion controls and locks on both axes; r. a. and declination setting circles (r. a. circle power driven); power panel with input/output connections for optional illuminated reticle eyepiece, electric focuser, and declination motor; equatorial wedge with compass, latitude scale, bubble level, micrometric azimuth control, deluxe latitude adjuster, and no-tool knob set; adjustable height tripod; audio instruction cassette; foam-lined carrying case with lock; lifetime warranty. *$3600 list.* Regularly $1799.

Brand-new first-line 2080/LX5, with MCOG, $1699!



A $5200 2120/LX5 for $1999!

2120/LX5: Here's a sensational limited time savings of over $3200 on the premier 10" telescope in the entire world -- the very newest Meade 2120/LX5. That's better than 61% off the list price! This special sale positively ends December 31, so don't miss this once-in-a-lifetime opportunity! Complete with all these features: 10" 2500mm f/10 optical tube that gathers 57% more light than an 8" scope; multi-coated optics group for 20% higher light transmission and increased contrast; metal dust cover; 9 x 60mm right angle finderscope with illuminated polar axis reticle (includes battery); 1/10th wave 2" multicoated star diagonal with 1 1/4" eyepiece adapter; 1 1/4" 26mm (96x) Super Plossl eyepiece; fork mount; LX precision worm gear drive; quartz-controlled sidereal rate electronic drive with power adapters and 25' extension cords for AC and 12 volt DC operation, plus battery pack for penlight battery operation away from all power sources; hand control with built-in map light, control for optional electric focuser, pushbutton controls for 2x drive corrector and 8x image scanning functions, switch-selected quartz/manual control and northern/southern hemisphere operation, variable rate control; manual slow motion controls and locks on both axes; r. a. and declination setting circles (r. a. circle power driven); power panel with input/output connections for optional illuminated reticle eyepiece, electric focuser, and declination motor; equatorial wedge with compass, latitude scale, bubble level, micrometric azimuth control, deluxe latitude adjuster, and no-tool knob set; adjustable height tripod; audio instruction cassette; foam-lined carrying case with lock; lifetime warranty. *$5200 list.* Regularly $2699. **2120/LX5, with MCOG, $1999!**

$600 11x80mm binoculars for $249!

11 x 80mm Meade Binoculars: Deep space observing at its most convenient! Wide 4.5° field of view shows all of Andromeda, provides spectacular views of open clusters. Complete with case, carrying straps, dust covers, tripod adapter. *$600 list,* for $249!

CREDIT CARD SALES

Sorry, but these special prices are so low that if you use a credit card to buy one of these sale items, we must add a small surcharge to the low cash prices shown to cover the fees charged us by the credit card companies for accepting your card. Add 2% to the prices shown if you use Mastercard, Visa, or Discover. Add 4% if you use American Express. Insured UPS shipping is still free to all 48 continental United States, and the prices shown are your total delivered cost if you pay by check or money order.

ad-libs **astronomics** Now in our ninth year of saving you money.

2401 Tee Circle, Suites 105/106, Norman, OK 73069

Toll-Free Order Line: **(800) 422-7876**

Use (800) 422-7876 for price quotes and credit card orders only.

Hours: Monday thru Friday, 10:00 AM to 5:30 PM CST.

Freight extra on Canadian, AK, HI, APO, and orders shipped by motor freight or air.

Tech Questions/Customer Service: **(405) 364-0858**

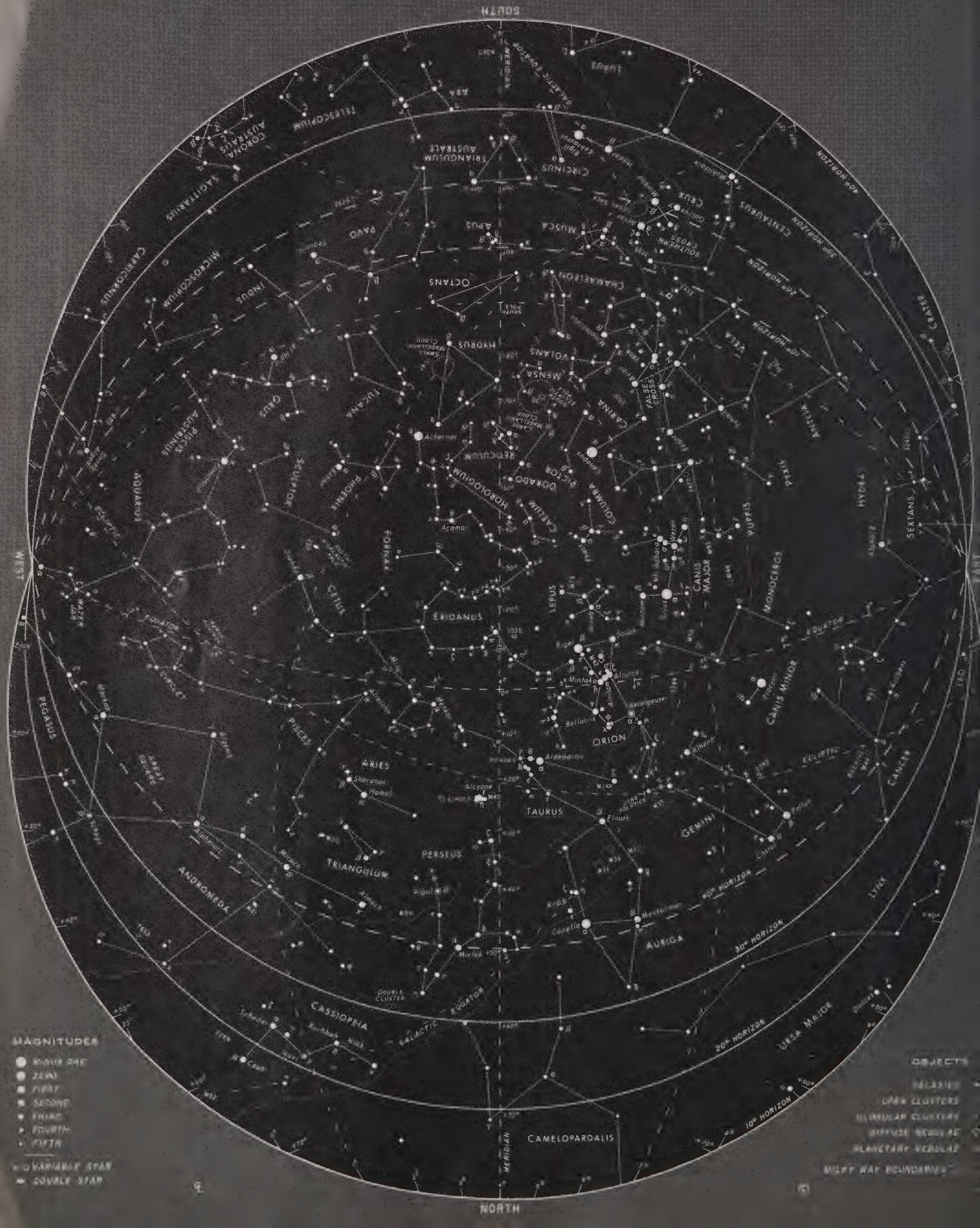
Use (405) 364-0858 for technical advice and all calls from AK, HI, and OK.

Mastercard, Visa, Discover, and American Express accepted.

$2 service charge on orders under $25. $5 COD charge. U.S. and Canadian sales only.

Southern Stars for December-January

The sky as seen from latitudes 10° to 40° south, at 11 p.m. and 10 p.m. local time on the 6th and 21st of December, respectively; also at 9 p.m. and 8 p.m. on January 5th and 21st. For other dates, add ½ hour for each week earlier, or subtract ½ hour for each week later.


SOUTH
WEST
EAST
NORTH
MERIDIAN
EQUATOR
ECLIPTIC
GALACTIC
40° HORIZON
30° HORIZON
20° HORIZON
10° HORIZON
OCTANS
HYDRUS
MENSA
VOLANS
CHAMAELEON
MUSCA
APUS
TRIANGULUM AUSTRALE
CRUX
CENTAURUS
CIRCINUS
ARA
TELESCOPIUM
CORONA AUSTRALIS
SAGITTARIUS
MICROSCOPIUM
INDUS
PAVO
CAPRICORNUS
TUCANA
GRUS
PISCIS AUSTRINUS
PHOENIX
SCULPTOR
AQUARIUS
RETICULUM
DORADO
PICTOR
HOROLOGIUM
CAELUM
COLUMBA
CARINA
VELA
ANTLIA
PYXIS
HYDRA
SEXTANS
CRATER
PUPPIS
MONOCEROS
CANIS MAJOR
CANIS MINOR
LEPUS
ERIDANUS
FORNAX
CETUS
PEGASUS
PISCES
ARIES
TAURUS
ORION
GEMINI
CANCER
LYNX
PERSEUS
TRIANGULUM
ANDROMEDA
AURIGA
CASSIOPEIA
URSA MAJOR
CAMELOPARDALIS
LEO
Achernar
Acamar
Rigel
Mintaka
Alnilam
Alnitak
Betelgeuse
Bellatrix
Aldebaran
Alcyone
Sheratan
Hamal
Elnath
Capella
Mirfak
Algol
Almach
Mesarthim
Alpheratz
Mirach
Schedar
Kochab
Caph
Double Cluster
Procyon
Pollux
Castor
Alhena
Regulus
Denebola
Kaus Australis
Nunki
Ascella
Kaus Media
Kaus Borealis
Sabik
Rasalhague
Alphecca
Antares
Shaula
Lesath
Kornephoros
Vega
Deneb
Altair
Fomalhaut
Enif
Markab
Diphda
Menkar
Menkent
Hadar
Rigil Kentaurus
Toliman
Miaplacidus
Canopus
Sirius
Adhara
Wezen
Aludra
Naos
Suhail
Avior
Miaplacidus
Gacrux
Mimosa
Hadar
Agena
Kochab
Polaris
Dubhe
Merak
Phecda
Megrez
Alioth
Mizar
Alkaid
Alcor
Thuban
Rastaban
Eltanin
Kochab
Polaris
Ras Algethi
Ras Alhague
Kornephoros
Sabik
Yed Prior
Yed Posterior
Unuk
Kaus Australis
Nunki
Ascella
Kaus Media
Kaus Borealis
Vega
Sheliak
Sulafat
Deneb
Albireo
Altair
Tarazed
Alshain
Dschubba
Graffias
Acrab
Dschubba
Antares
Rasalgethi
Sabik
Rasalhague
Cebalrai
Ras Algethi
Kornephoros
Vega
Rasalhague
Cebalrai
Ras Algethi

Rambling Through the Skies

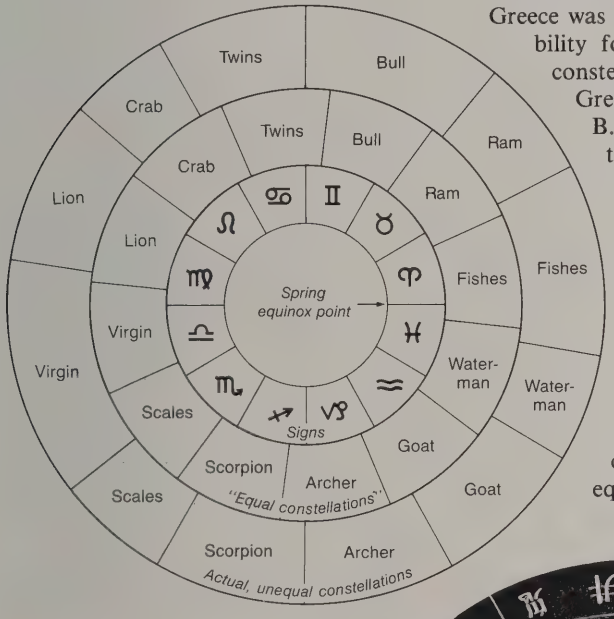
ZODIACAL SIGNS VS. CONSTELLATIONS

OUR NOVEMBER evening all-sky map on the next two pages shows the sky at the instant a very special point is on the meridian: the vernal, or March, equinox, which navigators still call the "First Point of Aries."

This term is a historic carryover from the time, some 2½ millennia ago, when the constellation of Aries the Ram *was* located at this equinox, and Cancer and Capricornus were, respectively, at the summer and winter solstices. The "tropics," or geographical latitude circles where the Sun shines from the zenith on those dates (at 23½° north and south of the equator), are still named for Cancer and Capricorn. The changes since ancient times are due to that often-mentioned precessional shift, which has drawn the zodiacal constellations away from their corresponding signs by approximately one constellation length.

The zodiacal signs, used only by astrologers nowadays, are 12 equal segments, each spanning 30° along the zodiac. This even division harks back to long before the understanding of precession. Moreover, the signs were originally not confined to the immediate ecliptic vicinity, but extended above and below all the way to the ecliptic poles like the skins of 12 equally sliced cantaloupe sections. In early star catalogues such as Ptolemy's, every star — whether a member of a zodiacal constellation or not — had its zodiacal sign listed. For example, Ptolemy stated that Polaris lay 0° 1/6′ into the sign of the Twins (Gemini).

The zodiacal signs and constellations approximately coincided when ancient Greece was in its prime. Indeed, responsibility for "officializing" the ancient constellations rests largely with the Greeks. It was not until about 130 B.C. that Hipparchus discovered the precession of the equinoxes. He noticed that his measurement of Spica's ecliptic longitude was some 2° greater than the value obtained by his Greek predecessor Timocharis a century and a half earlier. Hipparchus then found similar discrepancies with other measurements by Timocharis. He realized the vernal equinox was slowly "preceding"



Above: **The relationship between the constellations and signs of the zodiac can be seen in this diagram adapted from Norman Davidson's *Astronomy and the Imagination*. The true constellations (outer ring) have precessed counterclockwise from their classical positions (inner ring). *Right:* The Chinese zodiac consisted of 12 "monthly" regions like those of the Western zodiac (whose counterparts are indicated along the inside rim in the same orientation as above). Each sign also contained two or three of the 28 lunar mansions. Diagram adapted from *l'Astronomie Chinoise*.**

The Telescope Shirt

What the fashionable astronomer is wearing! Great conversation starters. A sport shirt with a little telescope embroidered where the alligator used to be. Buy one (or more); they make great gifts!

Available in red, white, lt. blue, tan & navy. S,M,L,XL

$16.95*

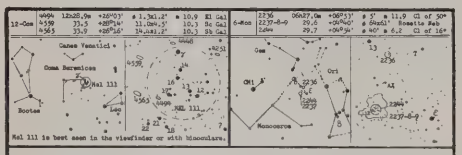
FREE CATALOGUE

To order: send check, money order, M/C or Visa number. *Include $2 postage & handling. Specify size and color. IL residents add 7% sales tax.

Or Call 1-800-457-8725 TOLL FREE

In IL call 1-312-456-8725

Vogel Enterprises, Inc., P.O. Box 3717, Oak Park, IL 60303



INDEX CARD FINDER CHARTS

Locate the best galaxies, nebulae, star clusters, with ease. 75 3x5 charts per set, for use at the telescope!

SET 1 MESSIER OBJECTS SET 2 NGC OBJECTS
SET 3 DOUBLE STARS SET 4 NGC, Part B
SET 5 NGC FOR LARGER SCOPES

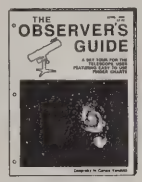
$7.50 ea., 2 or more **$7.00** ea., 4 or more **$6.50** ea.

THE OBSERVER'S GUIDE

A bi-monthly chart set for use at the telescope with easy to use finder charts, astrophotos, eyepiece impressions, & visual descriptions.

EACH ISSUE IS A SPECIAL SKY TOUR

an observer's reference guide of all deep-sky objects within a feature constellation on special data-chart pages.



U.S.A.: **$12** per year (six issues), **$21** two years.
CANADA: **$18** per year, **$33** two years.
OTHER COUNTRIES: **$18** per year, **$33** two years.

OBSERVER'S LOGBOOK

Only **$18.95**

Foreign postage $5.00

Contains 100 observing forms.

Large dew-resistant binder, blue with silver lettering
RECORD YOUR OBSERVATIONS
With 50 Planetary Forms & 50 Deep-Sky Forms

ASTRONOMY & SPACE SLIDES

SPACE SPECIAL: Gal; Neb; Sol. Sys.; Sun; 100 **$32.95**
20 SLIDE SETS — **$9.50 ea:** Apollo 11; Best Shuttle; Sun; Mercury; Venus; Mars; Jupiter 1; Jupiter 2; Saturn 1; Saturn 2; Uranus; Universe; Halley

40 COLOR SLIDES & TAPE — $14.95 ea.

Our Universe; Comet Halley; Apollo 11; Apollo 17; Saturn 1; Saturn 2; Jupiter; Mars-Viking; Mt. St. Helens; STS-1; STS-2; Dixon Space Art; Bonestell Space Art

VIDEO TAPES (VHS or BETA) $29.95 ea.

(*VHS-PAL): *America In Space; *Jupiter/Saturn; *Apollo 11; *Mars; *Satellite Rescue; *Shuttle 1-8; Comet Halley; Uranus; STS-1; JPL/Mars.

Astro Cards® *Phone: 412-295-4128*
P. O. Box 35, Natrona Heights, PA 15065

CATALOG: U. S. A.-50¢; Foreign-$1.50
FOREIGN ORDERS: add 20% for airmail

or moving westward among the stars. This, of course, is due to the 25,800-year wobble of the Earth's axis, but it took some additional centuries for an accurate determination of the cycle's length.

While the zodiacal constellations seem to drift eastward, away from the equinox, the classical sign sectors remain anchored to the season points along the zodiac. So the vernal equinox continues — as in ancient times — to mark the beginning of the sign of Aries, even though it's now among the stars of Pisces.

This sign-constellation discrepancy soon led to a distinction between two types of zodiacs: the sidereal, locked onto the stars and constellations, and the tropical, fixed to the Earth's seasons. Indeed, Ptolemy was largely responsible for introducing the concept of a tropical zodiac.

Many of these concepts are illustrated in the upper diagram on the previous page, adapted from Norman Davidson's book, *Astronomy and the Imagination*. It shows the current relationship between the zodiacal signs (inner ring), their corresponding constellations' positions assuming equal zodiacal lengths (middle ring), and the approximate actual extent of these constellations (outer ring).

However, the outer ring does not strictly represent the portion of the ecliptic in each constellation. For one thing, it omits the fact that the ecliptic actually runs through non-zodiacal Ophiuchus for some three times the distance that it does through adjoining Scorpius, a true zodiac member. But the idea of constellations having definite boundaries is rather recent. At the beginning of the 19th century, rough, curvy boundaries began to appear on star maps. The present well-defined straight ones have been with us for less than six decades.

The concept of a zodiac existed in non-Western cultures as well, whose members also appreciated the significance of the band of sky in which the Sun, Moon, and planets wander. The lower diagram on the previous page shows a traditional Chinese zodiac. Like ours, it contains 12 signs that make up the inner ring.

Yet the Chinese included other information on their zodiac. The symbols around the outer ring represent their traditional 28 "lunar mansions." By noticing the Moon's changing location in the sky from night to night, they created these mansions (also called houses or stations) so that the Moon could occupy one each day on its monthly circuit around the heavens. And since 28 mansions cannot fit evenly into 12 signs, the various zodiacal sectors have either two or three of these lunar stations apiece.

GEORGE LOVI
American Museum-Hayden Planetarium
New York, N. Y. 10024

This Holiday Season . . . Give the gift that arrives 12 times a year,

Sky & Telescope!

Special gifts for new subscribers to SKY & TELESCOPE!

Now is the time to remember that friend who keeps asking to look at your copies of SKY & TELESCOPE or that nephew or niece with a budding interest in the sky. There's an extra bonus for both of you if you act now! With every gift subscription, you and that special someone will each receive a copy of our 1988 GUIDE TO THE HEAVENS. Your recipient will also receive BACKYARD ASTRONOMY, a 32-page booklet of easy-to-understand how-to articles for the budding observer, as well as copies of OBSERVING WITH BINOCULARS, HOW TO CHOOSE A TELESCOPE, and WELCOME TO OUR UNIVERSE. With your gift subscription, we will send a thoughtful card signed with your name and message.

Please use the order form below.

Subscription Rates

☐ New ☐ Renewal ☐ Gift subscription for:

Rates:	1 year	2 years	3 years
United States and possessions	**$20.00**	**$37.00**	**$54.00**
Europe, Africa, West Asia (expedited delivery)	$35.00	$67.00	—
Canada, Mexico, elsewhere (by surface mail)	$23.50	$44.00	$64.50

Please note: The subscription rates listed above are complete. Do not add sales tax or postage charges. Please enclose payment. Foreign payments must be in U. S. funds drawn on a U. S. bank or by International Money Order.

Name .....

Address .....

City ..... State ..... Zip Code .....

Gift subscription: Please send **Sky & Telescope** to:

☐ New ☐ Renewal

Name .....

Address .....

City ..... State ..... Zip Code .....

Please send gift card and sign: .....

Use the space below to order SKY PUBLICATIONS advertised in this issue. They will be shipped to you unless you indicate otherwise.

Item No.	Description	Quantity	Price
.....	.....	.....	$ .....
.....	.....	.....	$ .....
.....	.....	.....	$ .....

Mass. residents add 5% sales tax. Foreign add 15% for postage. Foreign payments must be in U. S. funds drawn on a U. S. bank or by International Money Order.

ZIP CODE	P	T	B	EXPIRES

FIN. TRANS.	MONEY	NO.

Please do not write in this space.

Use this handy envelope
to order any Sky Publication in this issue

Binders for all of your issues of **Sky & Telescope**

Get organized — and get the most out of your issues of **Sky & Telescope.** Store and protect them in our sturdy **Sky & Telescope** binders. These very strong, custom-made binders have wire rods (just insert in the center of each issue) supported by metal end plates to hold the magazines firmly in place while permitting them to be opened fully. Each binder is beautifully covered in water- and stain-resistant book cloth with stylized gold-tone lettering on the front and spine. To order the correct binder, please note the year of the **Sky & Telescope** issues you want to store, as stated in the order line below.

From 1977 to 1984, **Order B0002 . . . $12.95**
From 1985 on, **Order B0003 . . . $12.95**
Special: Two or more **Sky & Telescope** binders (either kind) sent to the same address . . . **$11.00** each

Name .....

Address .....

City ..... State/Country ..... Zip .....

Fold Here

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 25274 BOSTON, MA

POSTAGE WILL BE PAID BY ADDRESSEE

SKY PUBLISHING CORPORATION

49 Bay State Road

P. O. Box 9102

Cambridge MA 02238-9913

EAST
WEST
SOUTH
ORION
TAURUS
PERSEUS
ANDROMEDA
LACERTA
CYGNUS
VULPECULA
DELPHINUS
SAGITTA
SERPENS (CAUDA)
ARIES
TRIANGULUM
PEGASUS
GREAT SQUARE
PISCES
EQUULEUS
AQUILA
SCUTUM
AQUARIUS
CAPRICORNUS
CETUS
ERIDANUS
LEPUS
CAELUM
FORNAX
SCULPTOR
PISCIS AUSTRINUS
MICROSCOPIUM
SAGITTARIUS
HOROLOGIUM
PHOENIX
GRUS
INDUS
PAVO
HYDRUS
TUCANA
ECLIPTIC
EQUATOR
GALACTIC EQUATOR
MARCH EQUINOX
WATER JAR
CIRCLET
SOUTH GALACTIC POLE
MERIDIAN
50° HORIZON
40° HORIZON
30° HORIZON
20° HORIZON
Rigel
Bellatrix
Aldebaran
Alcyone
Almach
Mirach
Alpheratz
Scheat
Markab
Algenib
Menkar
Alrescha
Mira
Diphda
Fomalhaut
Deneb Algedi
Algedi
Dabih
Nunki
Ankaa
Acamar
Achernar
Al Na'ir
Peacock
Magnitudes
Objects

Celestial Calendar

Conducted by Alan M. MacRobert

THE SUN, MOON, AND PLANETS THIS MONTH

LAST MONTH one brilliant planet, Jupiter, lit the early evening sky. Now suddenly there are two, as Venus reappears after sunset. Saturn also shines in the southwestern sky at dusk when November begins, but it's much fainter. It sinks into the twilight glow before the end of the month, passing Venus as it goes. Meanwhile, in the east before dawn, Mars grows a little more prominent and Mercury has its best morning apparition of the year.

Venus shines low in the southwest as darkness gathers, setting by the end of twilight. If you didn't notice Venus toward the end of last month, you'll see it now! It's close to the horizon but very bright at magnitude −3.9.

A telescope turned its way this month reveals a tiny, remote, featureless ball. See whether you can detect that it's not quite round. Venus shines so brightly that you'll want to observe it as soon after sunset as possible. (That way, twilight will help dilute the glare.) If you start watching the planet now and follow it until it flies between the Earth and Sun next June, you'll see Venus grow in apparent diameter as it gets closer to us, while it wanes to a beautiful slim crescent phase. See the illustration on page 514.

Saturn lingers in the southwest after sunset for much of November. At magnitude +0.5 it is 60 times fainter than Venus, but it's higher in the sky when the month begins. Saturn starts out about 21° from Venus on November 1st and slides about a degree closer every evening, finally passing 2° north of the brighter planet on the 20th. The two are a lovely sight around this time, a bright world and a relatively faint one shining near each other in the autumn twilight.

Saturn is backing into the Sun's glare as we rush ahead in our smaller, faster orbit around the Sun. The ringed planet lies more than 91 light-minutes from Earth at the end of November, its greatest distance yet this year. The star Antares, which was near Saturn all year up to now, deserts it this month by plunging into the sunset first.

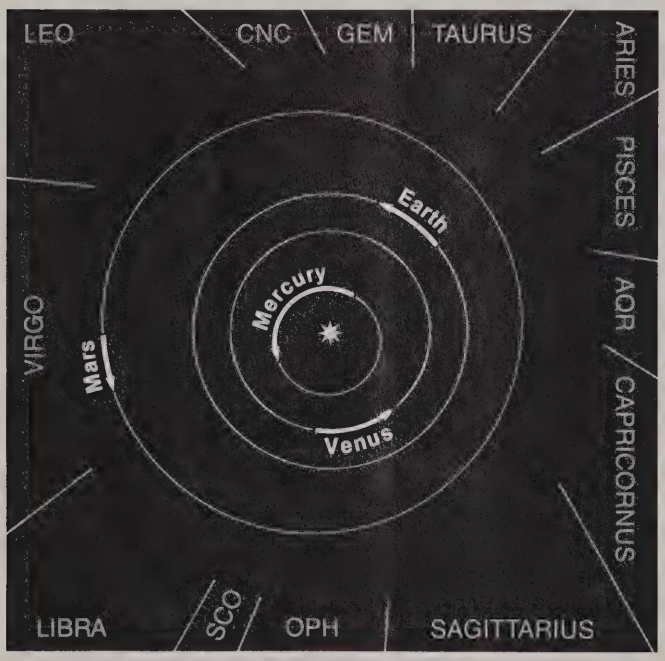
With so much of Earth's atmosphere between us and it, you wouldn't think of turning a telescope on Saturn this month to search for its moons or gaze at its marvelous rings. Or would you?

Jupiter continues to rule the night. At dusk it is already ascending in the east. Although not as brilliant as Venus, it shines in a dark sky long after Venus has set — a brilliant white beacon almost until dawn. Even Sirius, the night sky's brightest star (rising in late evening), pales in comparison.

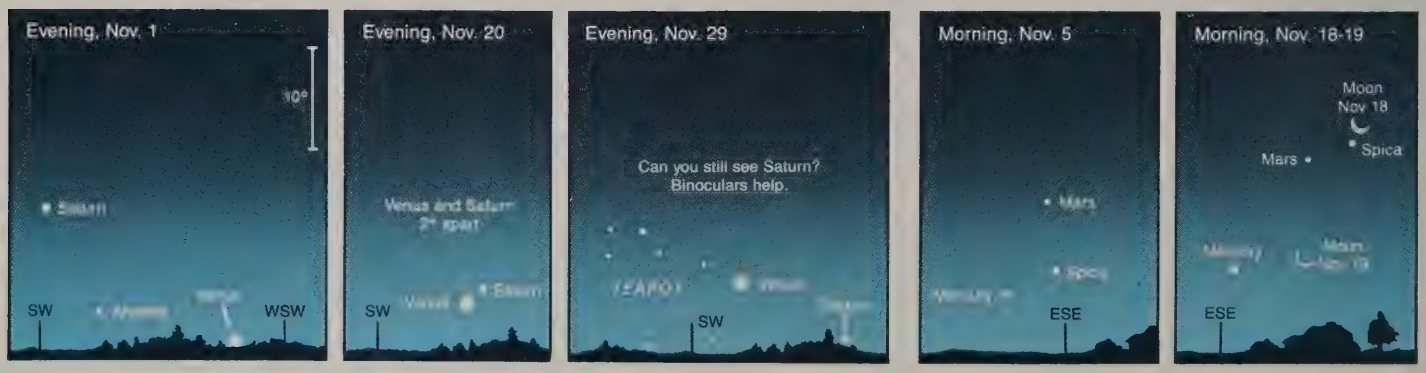
Binoculars or a small telescope reveal Jupiter's moons, engaged in their never-ending dance around the giant planet. Don't let the moons seduce you away from the body of Jupiter itself, however, especially around now when it appears near its largest. Jupiter's disk measured nearly 50 arc seconds across its equator last month when the planet came to opposition. By the end of November it is 46″ across — still gigantic!

Notice that Jupiter's edges are quite a bit dimmer than the rest of the disk. We always see this outer planet more or less fully lit, so the rim is where the Sun is rising or setting on Jupiter.

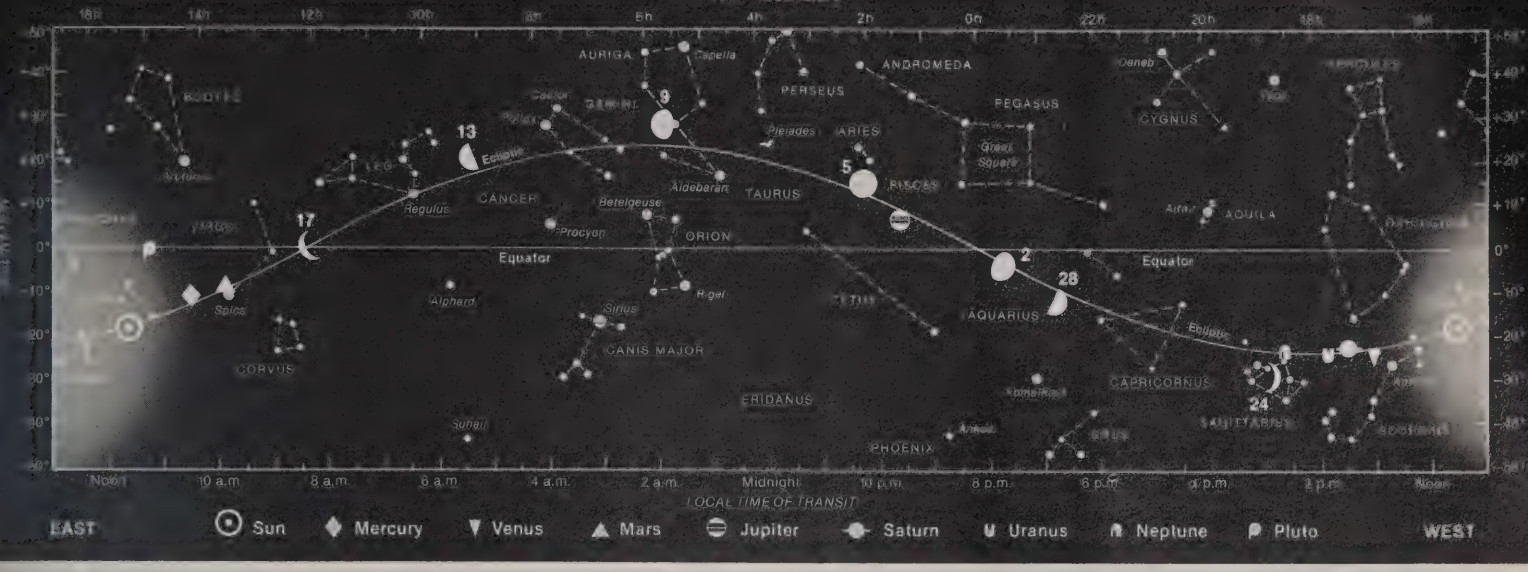
If Jupiter is still almost at its best, the situation won't last. It fades this month from magnitude −2.9 to −2.8 and will continually become fainter and appear for a shorter time each night until next April. Then Jupiter will slide back into the Sun's glare.



The inner solar system this month, seen from the north ecliptic pole. White arrows show where the planets move along their orbits during November. The directions to zodiacal constellations are marked from our viewpoint on Earth. Any straight line drawn from Earth represents an observer's line of sight, so laying a ruler across the chart clarifies many planetary arrangements in our sky. For instance, on November 15th (middle of arrows), we see Mercury near its greatest elongation to the Sun's right — in our morning sky — with Mars nearly behind it. Both planets are in Virgo.



Saturn sinks toward the southwest horizon in mid-twilight this month, followed by the Sagittarius Teapot, as Venus slowly rises higher. In the morning sky, Mars, Spica, and Mercury form a rapidly changing triangle. Diagrams from the Abrams Planetarium *Sky Calendar*.



The Sun, Moon, and planets against the stars. Positions are for midmonth unless another date is given. The Moon's position and phase are shown for 0^h Universal time every few days. *Local Time of Transit* tells when objects cross the meridian (are due south) at midmonth. Transits occur an hour later on the 1st and an hour earlier at month's end. Gray shading indicates the glows of sunrise (left) and sunset (right).

Uranus and **Neptune** follow Saturn down into the bright twilight glare this month. **Pluto** is beyond the Sun from Earth, in conjunction on November 2nd, and cannot be seen.

Mercury is visible in the dawn during almost all of November. It's elusive at first but brightens quickly and moves farther above the horizon as the days pass. Mercury is returning from behind the Sun at about the same time as another object: Spica, the brightest star in the constellation Virgo. Mercury lies 5° to the lower left of Spica on the 5th when they shine at nearly the same magnitude. You may need binoculars to see them in the growing light.

After that Mercury gets much brighter. It reaches magnitude −0.7 by the end of the month, when it still lingers in the predawn sky. At greatest elongation on the 13th, Mercury is 19° west of the Sun. That's not its greatest possible apparent distance from the Sun, but Mercury is easy to see this month because it stands nearly straight above the sunrise point. This is Mercury's best morning apparition for the year. Don't miss it!

PLANETARY DATA FOR NOVEMBER, 1987

Object	Date	R.A. h m	Dec. ° ′	Elong. °	Mag.	Diam. ′ ″	Illum. %	Dist. a.u.
Sun	Nov 1	14 22.6	−14 11	—	−26.8	32 16.7	—	0.993
	Dec 1	16 26.0	−21 41	—	−26.8	32 29.5	—	0.986
Mercury	Nov 1	13 52.6	−11 06	8 Mo	+2.9	9.5	5	0.704
	11	13 52.1	−9 06	19 Mo	−0.3	7.2	49	0.933
	21	14 36.6	−13 18	17 Mo	−0.7	5.7	81	1.174
	Dec 1	15 35.6	−18 28	12 Mo	−0.7	5.0	94	1.335
Venus	Nov 1	15 35.9	−19 28	18 Ev	−3.9	10.4	95	1.599
	16	16 54.4	−23 22	22 Ev	−3.9	10.8	93	1.545
	Dec 1	18 16.0	−24 43	25 Ev	−3.9	11.2	91	1.483
Mars	Nov 1	12 56.5	−5 03	23 Mo	+1.8	3.7	99	2.516
	Dec 1	14 09.9	−12 20	34 Mo	+1.7	4.0	97	2.353
Jupiter	Nov 1	1 27.1	+7 27	165 Ev	−2.9	49.3	—	3.991
	Dec 1	1 16.5	+6 32	132 Ev	−2.7	46.4	—	4.246
Saturn	Nov 1	17 10.6	−21 45	41 Ev	+0.5	15.4	—	10.770
	Dec 1	17 24.7	−22 03	14 Ev	+0.5	15.1	—	10.994
Uranus	Nov 16	17 38.0	−23 30	32 Ev	+5.7	3.5	—	20.074
Neptune	Nov 16	18 26.7	−22 20	43 Ev	+8.0	2.2	—	30.945
Pluto	Nov 16	14 51.5	−0 02	20 Mo	+13.8	0.1	—	30.603

For the principal members of the solar system, this table gives the right ascension and declination (equinox of date) at 0^h Universal time on selected days. Elongation is the angle in degrees between a planet and the Sun, in the morning (*Mo*) or evening (*Ev*) sky. Then follow the visual magnitude, and the apparent diameter of the object in arc minutes and seconds (neglecting phase). Only equatorial disk diameters are given; Jupiter's polar diameter is 93 percent of its equatorial diameter, while Saturn's polar diameter and ring extent are 89 and 225 percent, respectively. For planets that show an appreciable phase, the percentage of the disk diameter that is illuminated by the Sun is listed. Finally, distances of all objects from the Earth are expressed in astronomical units. One a.u. corresponds to 149,600,000 km or 92,960,000 miles.

Mars remains fairly inconspicuous, sitting above Mercury in the east-southeast before dawn. It rises about three hours before the Sun by month's end and attains a respectable height by the time dawn breaks. Still, Mars is rather faint. It brightens only to magnitude +1.7 during November.

In a telescope Mars is a *very* tiny reddish disk, not quite 4″ across — the same size as Uranus! There's not much of interest here now, but wait until next fall. This month Mars lies about 20 light-minutes from Earth. Next September it will be only 3¼ light-minutes away, and the Martian disk will measure 24″ across. Then even a small telescope should reveal a fat Mars capped with white polar regions and streaked with dark markings.

It's good that Mercury and Spica come into view below Mars this month. Although both outshine it, they make the red planet more noticeable than it would otherwise be. Mars is buzzing along steadily eastward against the background stars, and on the 12th it passes 3° north of Spica.

The **Moon** appears beside Jupiter on the 3rd. It lies near the Pleiades when a day past full on the night of the 6th, then near Aldebaran on the 7th, and Castor and Pollux late at night on the 10th. The waning Moon will draw attention to Regulus on the morning of the 14th and to Spica and Mars on the 18th. The next morning an old crescent hangs near the horizon, close by Mercury.

On the evening of the 22nd the slim young crescent may be seen low to the left of Venus and Saturn. On the 30th, the Moon is again close to Jupiter.

DEBORAH BYRD
McDonald Observatory
University of Texas
Austin, Tex. 78712

A Binocular Hyades Variable

AS AUTUMN NIGHTS grow frosty and stars begin shining through trees' bare branches, the Pleiades and Hyades make their evening appearance in the east.

The Hyades, highlighted by bright orange Aldebaran in the foreground, present one of the sky's most attractive binocular fields. Close to Aldebaran are several wide binocular double stars, among them Theta (θ) Tauri, a white and orange pair, and Sigma (σ) Tauri, both components white. Less than 4° northeast of Aldebaran is the loose open cluster NGC 1647, which can be resolved with almost any optical aid.

This rich field gets at least a brief look from most binocular observers whenever they're out starwatching in fall and winter. Night after night, year after year, it never seems to change. Or does it?

Just off the northern end of the Hyades' familiar *V* shape is a 5.9-magnitude star that sometimes fades to half its normal light. HU Tauri is an eclipsing binary with a period of 2 days 1 hour 21 minutes. Since this is close to 2 days exactly, the star's dimmings are only slightly out of step with the turning of the Earth. So every five weeks HU Tauri has a week-long "eclipse season" when it's dim every other evening.

The star remains near minimum light for a couple of hours. A complete eclipse, from the first trace of fading to full recovery, lasts about 8 hours.

The chart below shows comparison stars near HU for estimating its brightness. The numbers are magnitudes to the nearest tenth with decimal points omitted (59-67 means magnitude 5.9 to 6.7). Once you learn the comparison stars, it's easy to check HU Tauri at a glance whenever you look in on the Hyades.

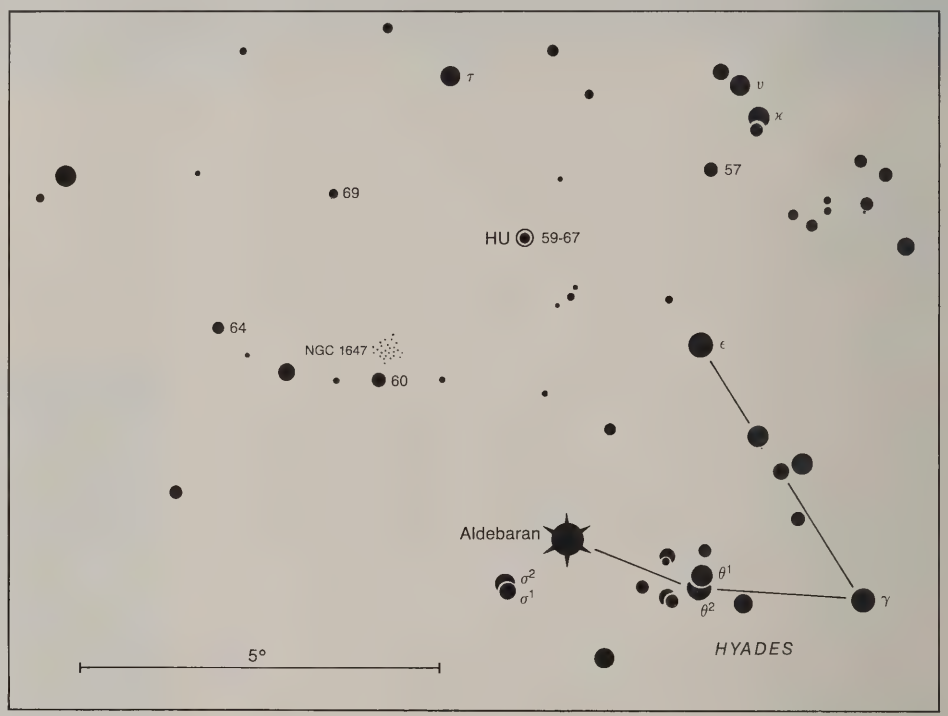
Here are the upcoming predicted Universal times of mid-eclipse. For North Americans, evening "eclipse seasons" occur in late October, late November, and early January.

October 22, 0:56; 24, 2:17; 26, 3:38; 28, 4:59; 30, 6:19.

November 1, 7:40; 3, 9:01; 5, 10:22; 7, 11:43; 9, 13:04; 11, 14:25; 13, 15:46; 15, 17:07; 17, 18:28; 19, 19:49; 21, 21:10; 23, 22:31; 25, 23:52; 28, 1:13; 30, 2:34.

December 2, 3:55; 4, 5:16; 6, 6:37; 8, 7:59; 10, 9:20; 12, 10:41; 14, 12:02; 16, 13:23; 18, 14:44; 20, 16:05; 22, 17:27; 24, 18:48; 26, 20:09; 28, 21:30; 30, 22:51.

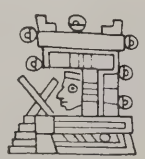
January 2, 0:13; 4, 1:34; 6, 2:55; 8, 4:16; 10, 5:38; 12, 6:59; 14, 8:20; 16, 9:41; 18, 11:03.



In Search of Ancient Astronomies?

ARCHAEOASTRONOMY

A unique **Journal** devoted exclusively to the study of the **Astronomies, Celestial Lore, Mythology, Religions** and **Cosmologies** of Ancient Civilizations and Surviving Native Cultures around the world.

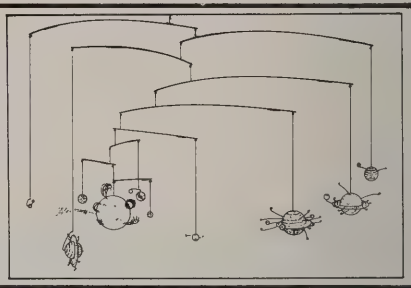


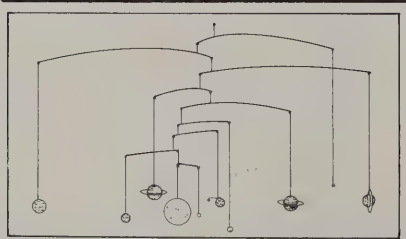
If the mysteries of **Maya Temples, Stonehenge, Egyptian Pyramids,** and the **Nazca Lines of Peru** fascinate you--
Write or call for free brochures on **ARCHAEOASTRONOMY** and our other publications or send $20 for the current volume ($30 for institutions).

The Center for **ARCHAEOASTRONOMY**
P.O. Box X, Dept. S
College Park, MD 20740
Phone: (301) 864-6637
Established 1977

ORBIC'S MAGNIFICENT SOLAR SYSTEM MOBILES — 3D and kinetic, fully assembled, prebalanced, ready to be hung. . . . A space-age must!

THE SOLAR FAMILY MOBILE — Meticulous planet detailing; 44 identifiable satellites (6 show features observed in recent flybys); unique coding system for satellite diameters and orbital directions; over 30 shades of colors; 3 planets with detailed rings; 9 stainless steel arms with micro-balancers; each planet floats freely in its own orbit; attachable Halley's comet model included. *Dimensions:* 70 inches max. orbital diameter (Pluto/Charon) x 30 inches drop from ceiling.
Cat. No. 0010-352 **Price $150.00** *





THE SPACE-SAVER SOLAR SYSTEM MOBILE — 15 shades of colors; Jupiter, Saturn & Uranus with rings; nine stainless steel arms allow each planet to float freely in its own orbit; Earth with orbiting moon; sunspots; belts & zones; red spot; beautifully crafted; excellent for students and for smaller areas.
Dimensions: 48½ inches max. orbital diameter (Pluto) x 26 inches drop from ceiling.
Cat. No. 0010-410 **Price $50.00** *

Send 39-cent SASE for color brochure and literature
*Contiguous U.S.A.; N. Y. residents add sales tax
ORBIC SYSTEMS INC., 109 Eltingville Blvd., Staten Island, N. Y. 10312 (718-356-2328)
Makers of Solar System Models & Mobiles for Schools-Homes-Offices

Jupiter's Great Red Spot

NOW that Jupiter has passed opposition, it's conveniently placed for evening viewing and will remain so through the winter. Jupiter's most renowned feature for telescope users is surely its Great Red Spot. But the spot is much less prominent visually than the planet's dark belts and bright zones. It has been very pale in recent years — a far cry from the brick red it has occasionally shown, which led to its perhaps overly dramatic name.

The spot is nestled between the bright South Tropical Zone and the dark South Equatorial Belt. It is surrounded by the Red Spot Hollow, a dark oval outline that's clearly visible even when the spot itself is not.

Jose Olivarez, a Jupiter recorder for the Association of Lunar and Planetary Observers (ALPO), described the spot in early August as "a dull, pinkish gray. It's quite a nice contrast, the pink oval set into the brownish belt." The colors are subtle, however, and require good seeing and a telescope that provides a high-contrast image. But there's no telling when the spot may become more strongly colored, like the bright orange it displayed in 1960 and 1961.

At what times can you see the spot? Jupiter rotates about once every 9 hours 56 minutes. A feature is well placed for viewing for only one-sixth of this time, 1 hour 40 minutes, if "well placed" is defined as being closer to the disk's central meridian than to the limb. (The central meridian is the imaginary line down the center of the disk from its north to south poles.)

Following are the Universal dates and times when the Red Spot is due to cross Jupiter's central meridian:

November 1, 7:27 and 17:22; **2,** 3:18, 13:14, 23:09; **3,** 9:05, 19:00; **4,** 4:56, 14:52; **5,** 0:47, 10:43, 20:38; **6,** 6:34, 16:30; **7,** 2:25, 12:21, 22:17; **8,** 8:12, 18:08; **9,** 4:03, 13:59, 23:55; **10,** 9:50, 19:46.

November 11, 5:41, 15:37; **12,** 1:33, 11:28, 21:24; **13,** 7:20, 17:15; **14,** 3:11, 13:07, 23:02; **15,** 8:58, 18:53; **16,** 4:49, 14:45; **17,** 0:40, 10:36, 20:32; **18,** 6:27, 16:23; **19,** 2:19, 12:14, 22:10; **20,** 8:06, 18:01.

November 21, 3:57, 13:53, 23:48; **22,** 9:44, 19:40; **23,** 5:35, 15:31; **24,** 1:27, 11:22, 21:18; **25,** 7:14, 17:09; **26,** 3:05, 13:01, 22:56; **27,** 8:52, 18:48; **28,** 4:43, 14:39; **29,** 0:35, 10:30, 20:26; **30,** 6:22, 16:17.

December 1, 2:13, 12:09, 22:04; **2,** 8:00, 17:56; **3,** 3:51, 13:47, 23:43; **4,** 9:39, 19:34; **5,** 5:30, 15:26; **6,** 1:21, 11:17, 21:13; **7,** 7:08, 17:04; **8,** 3:00, 12:56, 22:51; **9,** 8:47, 18:43; **10,** 4:38, 14:34; **11,** 0:30, 10:25, 20:21.

These predictions assume the spot will stay fixed at Jovian System II longitude 14°. It actually wanders somewhat in longitude, being carried along by atmospheric currents — a year ago it was at about 18° — so you may find that it transits the planet's central meridian a number of minutes early or late. Jupiter rotates through 1° of longitude about every $1^2/_3$ minutes.

See how accurately you can time the Red Spot's meridian transit. The best procedure is to estimate the meridian-crossing times of the spot's two ends, which transit about 40 minutes apart, as well as its center. Take the average of the three times.

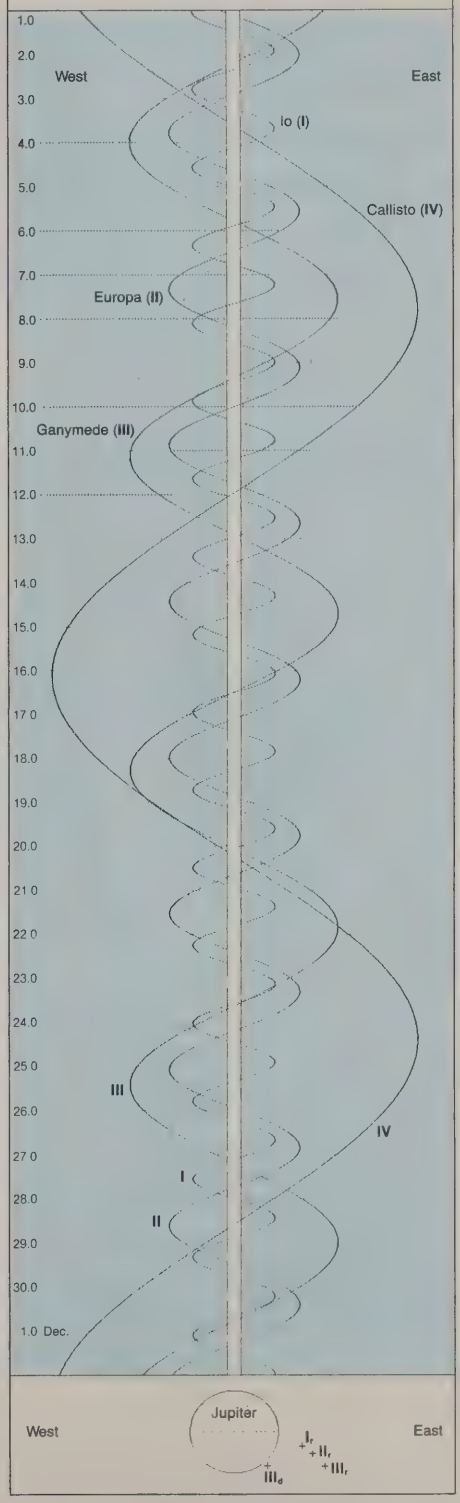
Olivarez would like to receive high-quality timings; his address is Omnisphere and Science Center, 220 S. Main St., Wichita, Kan. 67202. He can also provide more information on ALPO's Jupiter section for observers who would like to delve deeper into projects of this type.

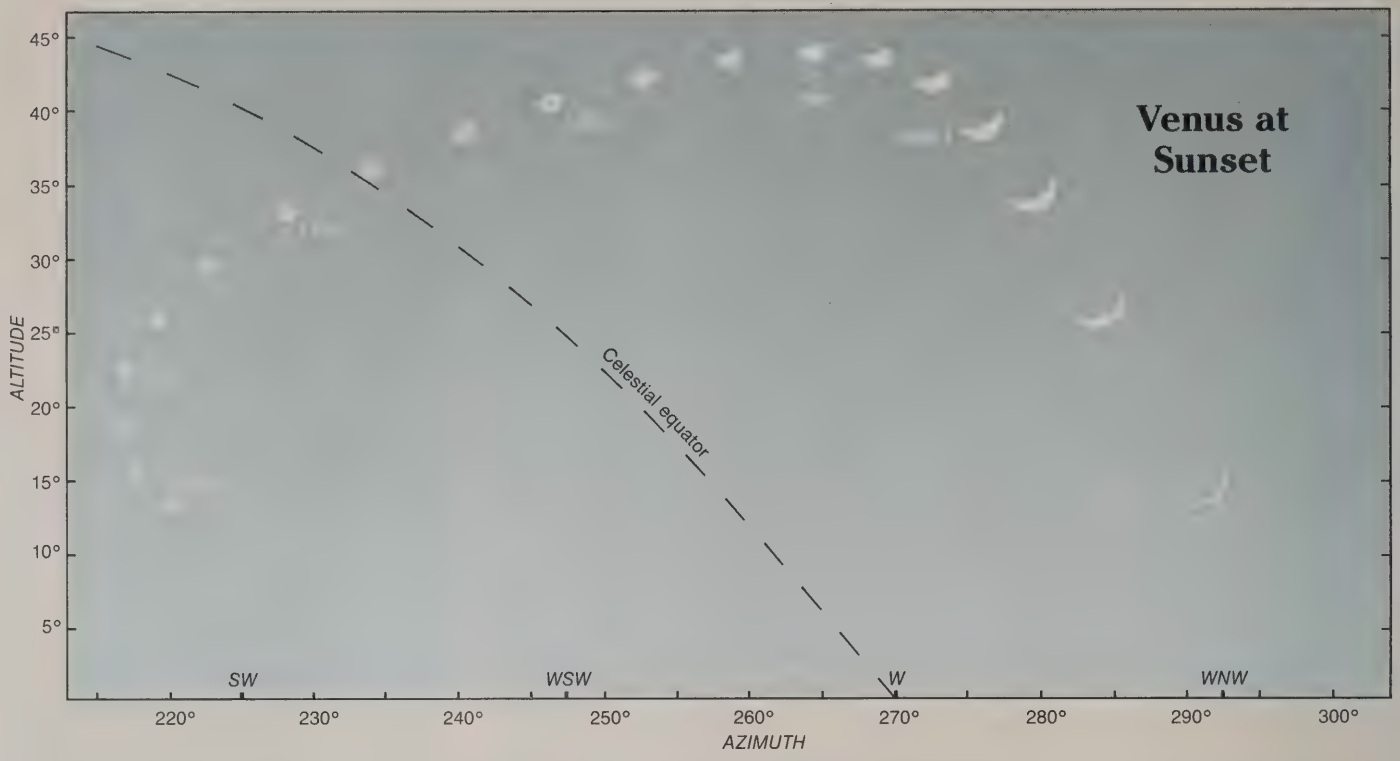
A. M.

Jupiter's Red Spot Hollow was "exceptionally prominent" when Stephen J. O'Meara observed it on September 10th. He used Harvard Observatory's 9-inch Clark refractor at 275x. The pale Red Spot itself was somewhat off center in the hollow, and no color was visible. According to some observers, reflectors show color on Jupiter more distinctly than refractors do.

JUPITER'S SATELLITES
November, 1987

The curving lines represent Jupiter's four bright (Galilean) satellites: **I,** Io; **II,** Europa; **III,** Ganymede; and **IV,** Callisto. Jupiter itself is indicated by the center pair of vertical lines. The horizontal lines mark 0^h Universal time on successive dates; 1 mm vertically is very nearly four hours. A curve is broken when the satellite is in the planet's shadow or when passing on its far side, perhaps being occulted. West is to the left and east to the right, to match the view seen by a Northern Hemisphere observer with an astronomical (inverting) telescope. The bottom section of the diagram shows where the satellites disappear (*d*) or reappear (*r*) during eclipses by Jupiter at midmonth. *Sky & Telescope* diagram.





VENUS IN THE EVENING SKY

Venus will be a brilliant "evening star" all winter and most of next spring. Already it can be found with binoculars very low in the southwest soon after sunset. For the next five months Venus will steadily brighten and climb higher in the evening sky. This diagram shows its changing position above the horizon at sunset for an observer at 40° north latitude. Also indicated are the planet's phase and apparent size as seen in a telescope, magnified 300 times with respect to the degree scale at left.

LARGEST SELECTION OF QUALITY TELESCOPE COMPONENTS

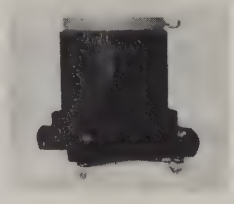
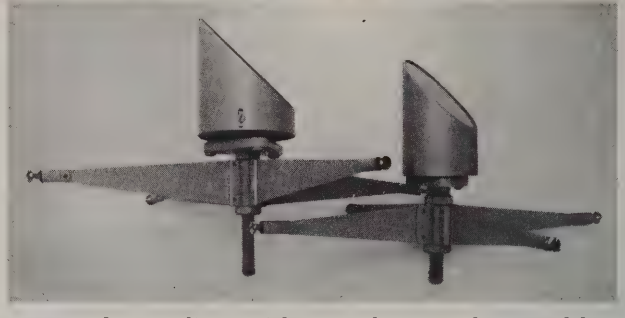


PHOTO-VISUAL FOCUSER for 2" eyepieces is less than 3" tall. Fits 5" O.D. or larger tubing for rich-field Newtonians with low vignetting. Also includes 1¼" adapter.
Model J **$34.95 ppd.**

2" FIRST FOCUS CAMERA ADAPTER for low vignetting and widest field. Available to fit most 35-mm cameras (specify brand). Most models **$19.95 ppd.**



Research-Quality Spiders and Secondary Holders

Largest selection of quality telescope components available from stock.

31 Newtonian mirror mounts, 4¼" to 20"
12 Cassegrain mirror mounts, 4¼" to 14¼"
33 Spiders, for tubing 5" to 24"
22 Diagonal holders, 1¼" to 4½" minor axis
6 Cassegrain secondary holders, 2.27" to 4.00"
11 Focusers, regular and Supershort
9 Focuser accessories
6 Star diagonals: .965", 1¼", and 2"
6 Ring mounts for guide telescopes

Plus tube counterweights, mirrors, and a booklet on Cassegrain telescopes

Our secondary-mirror holders are of an exclusive design for very low optical strain. Fully adjustable for collimation; axial and rotational adjustments are springless for positive locking and compact size. Lightweight aluminum construction with continuous retaining rim — no thick molded plastic, or tabs to increase diffraction. The holder's thin ribbed back reduces weight. Adjustable for secondary mirror thickness. Low overhang for stability.

Spiders feature very thin stainless-steel vanes tapered to a proper width at the lightweight aluminum center body. The very low mass of the unit, combined with the tapered vanes, gives exceptionally low vibration even for the relatively large diagonal used in medium and large telescopes, rich-field instruments, and many Cassegrain secondaries. Also curved spiders and low-cost convertible systems for dual Newtonian-Cassegrain telescopes.

JIM'S MOBILE MOTOFOCUS remote-control focusing with clutch drive installs quickly — no drilling or tapping.

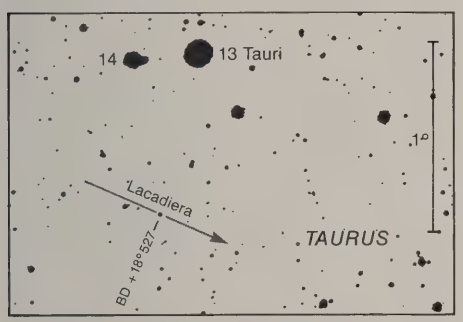
C5, C8, Celestron refractors, Meade Newtonian, Cave, Novak rack-&-pinion focusers (specify) $89.95 ppd.
C11, C14, Meade 2080, 2120 (specify) $98.50 ppd.

Kenneth F. Novak & Co.
Box 69F, Ladysmith, WI 54848 (715) 532-5102

OUR 19TH YEAR! Write or call weekday afternoons for free 86-87 24-page catalog. ($1.00 postage outside United States.)

Calendar Notes

Asteroid Occultation. Early on the evening of November 26th a 9.3-magnitude star near the Pleiades will be occulted by the minor planet 336 Lacadiera as seen from a narrow strip of territory from northern Quebec to the southwestern United States. The occultation will happen within a few minutes of 0:54 Universal time November 27th. The star is BD +18° 527, at right ascension 3^h $43^m.2$, declination +18° 51′ (2000 coordinates). It will wink out for up to 6 seconds, leaving only the 12.8-magnitude asteroid in view. For more information see last January's issue, page 70. North is up on the chart below, reproduced from Hans Vehrenberg's *Photographic Star Atlas.*



Lunar Occultation Reminder. On the evening of November 30th the dark limb of the waxing gibbous Moon occults 4.3-magnitude Epsilon (ϵ) Piscium for almost all of North America. Times are on page 68 of last January's issue.

Jovian Satellite Grouping. Three of Jupiter's Galilean satellites appear clumped together west of the planet on the evening of the 28th for North America. Their least separation is at 4:09 UT November 29th; from north to south they are Europa, Io, and Callisto. Prediction courtesy Jean Meeus.

November Meteors. The Taurid meteors are a weak but very long-lasting shower visible primarily in late October and the first two weeks of November. Under ideal conditions 15 Taurids per hour can be seen around their November 3rd peak, but this year the Moon is nearly full at that time.

"Many fireballs reported in the months of October, November, and December belong to this stream," write David Levy and Stephen Edberg in *Observe: Meteors,* an Astronomical League manual. A field mark of the Taurids is that they are among the slowest of meteors, encountering the Earth at only 28 kilometers per second.

Another November shower, the Leonids, peaks on the morning of the 18th when the early-morning sky is nearly free of moonlight. About a dozen of these very swift meteors may be visible per hour. Despite their low numbers, the Leonids tend to be bright and leave persistent trains.

Minima of Algol. November 1, 11:14; 4, 8:03; 7, 4:51; 10, 1:40; 12, 22:29; 15, 19:18; 18, 16:07; 21, 12:56; 24, 9:45; 27, 6:34; 30, 3:23.

December 3, 0:12; 5, 21:01; 8, 17:50; 11, 14:39; 14, 11:28; 17, 8:17; 20, 5:06; 23, 1:55; 25, 22:45; 28, 19:34; 31, 16:23.

These are the Universal dates and times when the prominent eclipsing variable star Algol should be at minimum brightness, 1.3 magnitudes fainter than normal. It is nearly this faint

Moonwatcher's Corner

The full Moon of November always shines near the Pleiades. It is somewhat to their west when full phase comes early in the month, as it does this year. November's full Moon is called the Frosty or Beaver Moon. This year it is also the Hunter's Moon, the one following Harvest Moon.

LUNAR PHENOMENA

(Times and dates are Universal time)

Full Moon	November 5,	16:46
Last Quarter . . .	November 13,	14:38
New Moon	November 21,	6:33
First Quarter . . .	November 28,	0:37
Full Moon	December 5,	8:01
Last Quarter . . .	December 13,	11:41
New Moon	December 20,	18:25

	Apsis	*Distance*	*Diameter*
Apogee	Nov. 12, 18^h	404,400 km	29′ 33″
Perigee	Nov. 24, 15^h	366,810 km	32′ 35″
Apogee	Dec. 10, 14^h	405,117 km	29′ 30″
Perigee	Dec. 22, 11^h	361,259 km	33′ 05″

Maximum and Minimum Librations

	Date	*Amount*	*Limb angle*
Min.	Nov. 1.8	3°.2	296°
Max.	Nov. 8.3	7°.9	214°
Min.	Nov. 14.9	4°.0	134°
Max.	Nov. 21.7	7°.2	35°
Min.	Nov. 28.8	4°.2	293°
Max.	Dec. 5.5	7°.7	214°
Min.	Dec. 11.9	3°.9	139°
Max.	Dec. 18.4	8°.2	50°

The Moon does not always present the same face to us; it rocks or "librates" slightly, showing first one limb well, then another. *Limb angle* gives the point on the Moon's edge tilted most toward us, measuring counterclockwise from the lunar north pole (0°) toward lunar west (Oceanus Procellarum, 90°) and on around. Values for other dates can be estimated between the listed extremes. For example, at full Moon on November 5th the Petavius region, near limb angle 250° south of Mare Fecunditatis, is tilted about 6° into view compared to its mean position. The listed values are geocentric; they do not include the small diurnal libration. For more information see the July issue, page 60.

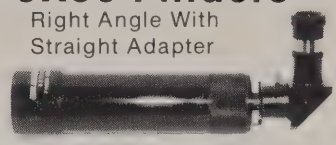
I. R. VIEWER (METASCOPE)

- Good Condition
- Uses 1.4 Mercury Battery (included)
- Eyepiece fixture included
- Carrying Case
- Documentation

$350.00

(714) 882-5789
ALLEN R. GLANZE (714) 883-2728
P.O. Box 6274, San Bernardino, CA 92412

8X50 Finders
Right Angle With Straight Adapter



Only $59.95

Celestron. Original equipment on SC8's Twist-Focus. Classic Black. New! Mounting Brackets: Newtonians - $22.50 C8/2080 (specify) - $37.50, or make your own.
VISA • MC • CHECK

astro-tech
101 WEST MAIN ■ P.O. BOX 2001
ARDMORE, OKLAHOMA 73402
405/226-3074
30 Day Money-Back Guarantee!

ASTRONOMICAL CALENDAR 1988

by Guy Ottewell

Fifteenth edition of this famous guide to the night sky for the whole year. Nearly 70 very large pages crammed with information, diagrams, graphic text and full explanations.

$12.00 (includes postage) from: Astronomical Workshop, Furman University, Greenville, S.C. 29613, U.S.A. ***Make check to 'Astronomical Calendar.'***

ASTROPHOTOGRAPHERS

PinPoint Focus - *Guaranteed!*

Even if you've taken only a *few* astrophotos, you know how difficult it is to achieve perfect focus of a star image when looking through the viewfinder of your SLR. The reason is . . . your eyes have the ability to accommodate slight defocusing of your telescope. What appears to be in focus *may not be* . . . especially at four o'clock on a cold morning!

What you need is a device which *guarantees* correct focus *every time,* and *instantly* shows you, vividly and graphically, *exactly* where pinpoint focus is.

SureSharp™ from Spectra Astro-Accessories *is* that device! It was developed by an astrophotographer who believes that, when you consider your investment in equipment, film, processing, and *time,* even *one* out-of-focus exposure is *one too many! SureSharp*™ is custom-made to fit your brand of camera and works with *all* telescope systems. ***SureSharp***™ is American-made to high standards and machined to exacting tolerances.*

The *introductory* price, direct from the manufacturer, is only **$98.50** postpaid anywhere in North America. California residents please add 6% sales tax. Check or money order OK - sorry no CODs. Order your ***SureSharp***™ today!

Yes! I want to put an *end* to out-of-focus astrophotos! Enclosed is my check or money order for $_____ for # _____ ***SureSharp***™ focusing device(s).

Name: _____
Street: _____
City: _____ State: _____ Zip: _____
35mm SLR brand and model: _____

Spectra Astro-Accessories
8726-D S. Sepulveda Blvd.
Suite 441
Los Angeles, CA 90045
(213) 649-3842
8-6 Mon thru Fri
10-2 Sat (Pacific Time)
Free brochure on request.
*PAT. PEND

CUSTOM TELESCOPE MOUNTS

Precision equatorial telescope mounts engineered and machined by AB Machining.

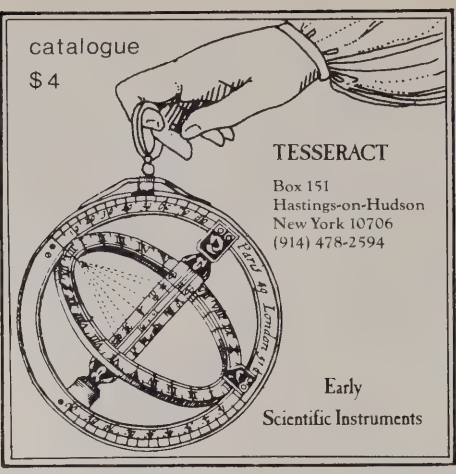
Sturdy, functionally designed mounts made of stainless steel and aluminum.

Prices start at $1,700.00. Send for free literature.

Alan Bell
AB MACHINING
5734 Industrial Road
Fort Wayne, Indiana 46825
219-483-1418

Quality machining for ATM's

catalogue
$4



TESSERACT
Box 151
Hastings-on-Hudson
New York 10706
(914) 478-2594

Early
Scientific Instruments

TeleVue Optics from Cosmic Connections

Plossls 50° Field (except 40mm)

Focal Length	O.D.	Price
55mm	2.00"	$203
40, 32mm	1.25"	102 each
26, 21, 17, 13		
10.5, 7.4, 1.8x, 2.5x	1.25"	86 each

Naglers 82° Field of View			Wide Fields 65° Field of View		
13mm	2/1.25"	$278	40mm	2.00"	$325
11mm	2/1.25"	263	32mm	2.00"	255
9mm	2/1.25"	243	24mm	1.25"	180
7mm	1.25"	203	19mm	1.25"	165
4.8mm	1.25"	165	15mm	1.25"	150

NEW!! 12mm, 16mm, & 20mm Nagler - CALL
TERMS: Check, money order, Visa, MC, Amex
Signature required for credit cards
IL residents add sales tax
Add $3.00 for postage -- Foreign orders add $15.

Cosmic Connections, Inc.
1460 N. Farnsworth Avenue
Aurora, Illinois 60505
312-851-5353
VISA MC American Express
Prices subject to change due to fluctuating dollar value overseas.

Meade®
THE LEADER'S EDGE

IN STOCK
7x50 Binoculars
97E
2045/LX3
320
2080/LX5
8800

CHICAGOLAND'S ASTRONOMICAL HEADQUARTERS

Cosmic Connections, Inc.
1460 N. Farnsworth Avenue
Aurora, Illinois 60505
312 851 5353
VISA MC American Express
Catalog $2.00

You know the story.

You've almost finished setting up your telescope when one of the kids decides to help by loosening a few of the thumbscrews.

Oh, he's helpful, all right.

Particularly if a cracked fork arm and bent worm gear are what you're after.

But don't worry.

Our shelves are full of broken equipment.

That's because we at the F.C. Meichsner Co. of Boston don't just *sell* binoculars and telescopes—we *fix* them, too.

And we have 71 years of experience.

So if you want great equipment at competitive prices—or the best repair department on the East Coast—do what people all over the country do.

Call us.

A lot of the telescopes and binoculars in our store are broken, and we're mighty proud of it.

F.C. Meichsner Co.
182 Lincoln St., Boston, MA 02111
(617) 426-7092
Specializing in CELESTRON® and other fine telescopes and accessories.
We accept MasterCard, Visa, American Express, and Discover.

for about two hours. These geocentric predictions, based on observations from 1970 to 1975, are calculated from the heliocentric elements Min. = 2,440,953.4657 + 2^d.8673075 *E*.

Variable Star Maxima. November 5, RR Sagittarii, 194929, 6.8; 17, RR Scorpii, 165030, 5.9; 19, V Cassiopeiae, 230759, 7.9; 25, RV Sagittarii, 182133, 7.8; 27, U Orionis, 054920a, 6.3; 27, S Ursae Majoris, 123961, 7.8; 28, S Hydrae, 084803, 7.8; 30, R Sagittarii, 191019, 7.3.

December 5, R Aquilae, 190108, 6.1 (see chart, August, 1985, page 149); 9, T Centauri, 133633, 5.5; 10, S Coronae Borealis, 151731, 7.3; 15, SS Virginis, 122001, 6.8; 16, R Centauri, 140959, 5.8; 20, T Columbae, 051533, 7.5; 21, RS Librae, 151822, 7.5; 26, T Ursae Majoris, 123160, 7.7; 26, V Bootis, 142539, 7.0.

The data above are, in order: the day of the month near which the star should be at maximum brightness; the star name; the star designation number, which gives rough right ascension (first four digits) and declination (boldface if southern); and the star's typical visual magnitude at peak brightness. Individual maxima may be brighter or fainter and many days early or late. All predictions are by Janet Mattei using recent data of the American Association of Variable Star Observers, 25 Birch St., Cambridge, Mass. 02138. Stars are listed if brighter than magnitude 8.0 at average maximum.

Accurate Time Signals. Astronomical events must sometimes be timed to an accuracy of better than a second. Persons with shortwave radios can receive continuous time signals by tuning to WWV, the National Bureau of Standards station, which broadcasts on frequencies of 2.5, 5, 10, 15, and 20 MHz, or the Canadian station CHU, which transmits at 3.330, 7.335, and 14.670 MHz.

People without shortwave radios can get accurate time ticks over the telephone by calling 900-410-TIME. This number provides access to the U. S. Naval Observatory master clock in Washington, D. C.

Universal Time (UT). In *Sky & Telescope,* many events are given in Universal time. UT is used around the world by astronomers and others who need to avoid confusion between time zones. It is expressed in the 24-hour system, from the start of one day to the start of the next.

To convert a UT time and date to a standard time and date in North America, subtract the following hours: EST, 5; CST, 6; MST, 7; PST, 8; Yukon, 9; or Hawaii, 10. (To obtain daylight saving time, subtract 4, 5, 6, 7, or 8 hours instead.) If you get a negative time, add 24 hours; in this case the result is on the date before the UT date given. For example, 6:45 UT November 9th is 1:45 a.m. on the 9th EST and 10:45 p.m. on the 8th PST.

Universal times are sometimes expressed as decimals of a day to simplify calculations. Thus 12:00 UT November 9th is November 9.5.

Skyline: Our Telephone News Service. To inform readers of fast-breaking news such as comet and nova discoveries, *Sky & Telescope* maintains Skyline, a dial-up telephone news service. The three-minute recorded message is updated every Friday afternoon, or more often if news warrants. The Skyline number is 617-497-4168. Regular toll charges apply.

CHRISTMAS SPECIAL!
DEEP-SKY OBJECT INVENTORY

For your IBM PC or Compatible or Commodore 64/128
Over 1,800 Nonstellar Objects
(IBM version)

Select by:
* Constellation
* Max. Magnitude
* NGC Range
* Object Type
* Messier No.

Display, print or transfer
ONLY $34.95
(Regular Price $59.95)

******

BONUS OFFER

Astrophotography Plan and Slide Data Base Software
$9.95 when ordered with above.
Order must be received by December 31, 1987.
This offer will not be repeated.

******

Send check or money order to:
AA STAR SYSTEMS
P. O. Box 1042
Fair Oaks, CA 95628
(916) 782-4061
Calif. residents add 6% sales tax.

Half-Price Artwork Sale

Flandrau Planetarium Mural

Imagine a beautiful astronomical painting displayed in your observatory, study, or living room. Here, in one sweeping statement, a modern artist has portrayed our search for fulfillment in science and art through the ages. Our full-color print of **Man and the Universe** is at one-seventh the scale of the magnificent original that is viewed by visitors to the Grace R. Flandrau Planetarium in Tucson, Arizona.

In a beautifully illustrated companion piece — a 24-page booklet of **Interpretative Comments** — former Flandrau director O. Richard Norton and artist Donald R. Cowen explain at length the concepts and events represented by the 10 phases of humanity's development shown in the mural.

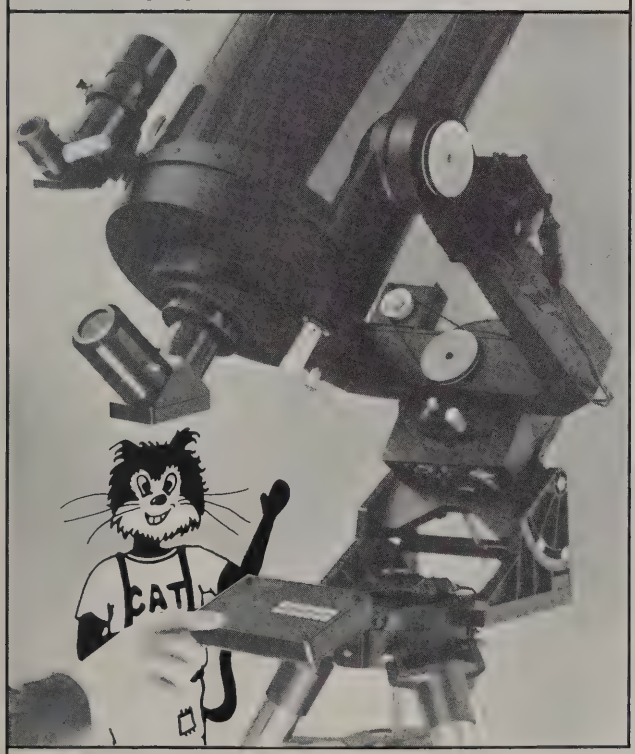
This 30-by-16-inch reproduction of the mural is printed on heavy white paper with generous borders suitable for framing, with an overall size of 35 by 23 inches. The explanatory booklet is mailed together with the full-color print in a sturdy tube.

Order 46212 *SALE PRICE* . . . **$2.99**

Mass. residents add 5% sales tax. Foreign add 15% for postage. All payments must be in U. S. funds drawn on a U. S. bank, or by International Money Order. **Use the order form in the center of this issue:**

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, Mass. 02238-9102

THE CAT ON A MEADE 10" SCT



Advanced Technology Instruments
P.O. Box 246
Carmel Valley, CA 93924
(408) 659-0437

SEE 100 GALAXIES PER HOUR!!!

Is that possible? With the CAT it's easy! The CAT is the Computer Aided Telescope accessory that attaches to most commercial telescopes in minutes with simple hand tools. It's compact, consumes less than 10 watts, and uses precision optical encoders to monitor RA and DEC with more than 25 times the resolution of most setting circles.

The CAT will help you polar align quickly and accurately. Finding objects takes only seconds with the RED CROSS pointing guide. Want to see M22? Just press **M22 ENTER.** The object identity, type, size, brightness, visual quality, and more are displayed on large, night-vision red displays. To center M22, just move your scope until the RED CROSS elements converge, and observe. It's so easy!

You can also tell the CAT to select objects for you! Just enter the characteristics of the objects you want to see, such as type, brightness, size, visual quality, minimum altitude. The CAT will find objects that satisfy these criteria, describe them, and guide you to them.

Want to know what's in the field? The CAT will identify the deep-sky object nearest the center of the field and display the total number in the field, **even as you move your scope!** Perfect for comet hunting!

The CAT contains more than 8000 astronomical objects, including the 250 brightest stars, 100 interesting double stars, the famous Messier Catalog of 110 deep-sky wonders, and the new deep-sky observer's standard — the 7840 entry **CNGC.**

Brackets for mounting the precision optical encoders to C8, C11, C14, M8, M10, and other commercial telescopes are available. An RS-232 option can be ordered to interface the CAT to computers and printers. It is usually straightforward to adapt the CAT to custom instruments. Send $5 for an informative 80-page User's Manual.

IMPORTANT: The suggested retail price is scheduled to increase from $1495 to $1995 on Dec. 1, 1987. Order now and **save.**

ASTRO AUDIO

TAPES TO SEE BY

FIELD GUIDE TO THE SOLAR SYSTEM

Your own Planetarium presentation ANYTIME, ANYWHERE!

With the assistance from **NASA** and narration by **Albion Watts** you have the legends, history and current data of the world's oldest science in an audio format . . . unveiling the Solar System.

Four volumes - Each volume contains *two 1-hr.* audio-cassette tapes. Moisture-resistant. Dustproof case. Quality and Durability.

UNCONDITIONAL LIFETIME REPLACEMENT GUARANTEE

When books/videos are least useful, these tapes travel with you . . . into the night sky.

INTRODUCTORY OFFER

Purchase Vol. I - JUPITER and MARS at $29.95 and we'll pay shipping and handling.

[ ] Enclosed is my check/money order.
Or charge my [ ] VISA [ ] MASTERCARD
[ ] Please send additional information
CC # _____ Ex. Date_____
Signature _____
Name _____
Address _____
_____ Zip _____

Send to: ASTRO AUDIO COMPANY
P.O. BOX 543, 139 MAIN STREET
IVORYTON, CT 06442 (203) 767-0525

ST-1

Catalogue/Data Package, $3

IMPORT EXPORT

BAUSCH & LOMB

4000 $395

With Wedge and Tripod **$495**

Technical Specifications

Clear Aperture	4"
Secondary Obstruction	35mm
Cassegrain Focal Length	1200mm
Resolution Limit	1.1 ARC/SEC.
Useful Magnification	30-240x
Photographic Speed	f/11
Image Scale (field of view)	1°/inch
Faintest Magnitude	12
Unvignetted Field	1.850" circle
Near Focus	15 feet
Finderscope Size	4x
Eyepieces	30mm, 18mm

8001 $1,039 — 6000 Pro $749

Dealers' limit: 5 units

"WE HAVE IT ALL!"

PAULI'S WHOLESALE OPTICS DIV.
29 Kingswood Rd.
Danbury, CT 06811 U.S.A.
(203) 746-3579

MasterCard · Credit · Charge · VISA

6 DAYS • 9am-6pm EST

Established 1914

Proudly made in USA by USA mfr.

ASTROPHOTOGRAPHY!

SKY SCIENTIFIC Astrocamera Model CL uses 9 different color and black-&-white Polaroid® Instant Films including Type 612 Ultra High Speed ASA 20,000! Model CL comes complete and ready to use with ground-glass focusing, pneumatic control low-vibration shutter, built-in T-mounting ring, and full instructions. Instant Astrophotography for **ALL** telescopes. **Only $195**

Model CL

Model C45 Astrocamera uses conventional 4 x 5 sheet films. Features 2" O.D. barrel mount, 3.0" near-focal-plane low-vibration shutter, ground-glass focus. For telescopes that accept 2.0" oculars. **$295.**

Add $3.50 insurance/shipping/handling in USA. California residents add 6% sales tax. VISA/MasterCard accepted. Send $1.00 for our new illustrated catalog.

SKY SCIENTIFIC
P.O. Box 184 - Skyforest, California 92385
(714) 337-3440

NEWTONIAN RICH-FIELD TELESCOPES

- Guaranteed 1/20-wave optics
- Enhanced coatings
- Anodized aluminum tube
- New Dobsonian mountings

TUBE ASSEMBLIES		OAK MOUNTINGS	
RFT-6 (6" F/5)	$365	PH-6	$130
RFT-8 (8" F/5)	$550	PH-8	$160
RFT-10 (10" F/5)	$895	PH-10	$550
RFT-14 (14 1/2" F/5)	$2,295	PH-14	$700

CUSTOM OPTICS — GUARANTEED 1/20-WAVE

TOTALLY HAND-FIGURED. Each fine-annealed PYREX mirror is precision NULL tested, quality aluminized and quartz overcoated, and finally STAR tested to assure professional observatory performance. Surface Accuracy: 1/20-wave peak-to-valley with helium-neon laser (6328 Angstroms). Thickness ratio: 1:6.

	PARABOLIC MIRRORS FOR NEWTONIAN TELESCOPES	CLASSICAL CASSEGRAIN SYSTEMS	ADD FOR ENHANCED COATING
4 1/4"	$150	N/A	$15
6"	$190	$290	$25
8"	$265	$380	$30
10"	$475	$650	$40
12 1/2"	$750	$1,050	$75
14 1/2"	$1,450	$1,800	$125
16"	$2,100	$2,500	$150
18"	$3,400	$3,900	$175
20"	$4,300	$4,900	N/A

N/A = Not Available. Larger Mirrors, up to 40", available. Quotations sent on request.
PARABOLIC MIRRORS: Specify focal ratio desired, F/4 to F/10
CASSEGRAIN SYSTEMS: F/16 System with F/4 Primary or F/20 system with F/5 Primary. Please specify.

ALL CUSTOM OPTICS: Minimum 50% cash (check) deposit, balance prior to shipment. **SCHOTT ZERODUR** available at extra cost. Add amount shown for **ENHANCED ALUMINUM COATING** for Newtonian or Cassegrain systems (includes enhanced coating of Flat when ordered with parabolic primary.)

ELLIPTICAL OPTICAL FLATS

Aluminized and overcoated. Fine-annealed PYREX. Minimum thickness ratio: 1:6. Surface Accuracy: 1/20-wave. Price includes shipping and insurance.

Minor axis dimension:			
0.75"	$18	1.83"	$30
1.05"	$20	2.14"	$38
1.30"	$21	2.61"	$50
1.52"	$25	3.10"	$75
		3.50"	$195

Add $10 for Enhanced Coating.
Larger Sizes: Custom Order.

ALUMINIZING

	REGULAR (90%)	ENHANCED (96%)
4 1/4"	$25	$50
6"	$35	$70
8"	$45	$90
10"	$60	$120
12 1/2"	$80	$140
14 1/2"	$135	$250
16"	$180	$280

PRICE INCLUDES RETURN SHIPPING AND INSURANCE. Secondary coated free if sent with primary. Add $10 to remove old coating.

MIRROR KITS

EACH KIT CONTAINS THE FOLLOWING:
- Fine-annealed PYREX® mirror blank.
- Hard Ceramic Tool. A ***Telescopics*** exclusive. Hardness matched to PYREX® (far superior to plate glass).
- Proven series of six abrasives.
- Cerium Oxide polishing compound; professional, premium-grade rare earth powder for fast, smooth optical polishing.
- Gugolz Polishing Pitch (made in Switzerland); used by professional opticians around the world.

SIZE	PRICE
4 1/4"	$42.50
6"	$54.00
8"	$79.50
10"	$148.00
12.5"	$230.00

Telescopics

All prices include shipping in continental USA. Complete Catalog $2.00 ($3.00 foreign). Foreign orders send first for Pro Forma invoice. Visa and Mastercard accepted. California residents add sales tax.

P.O. Box 98 • La Canada, CA 91011
(818) 341-8178 M-W-F, 9 a.m. to 4 p.m.

Authorized Meade Dealer

Meade

SUPER SALE!

Shown: 2120/LX3 MCOG

Includes Hand Control Unit!

Meade's famous 10" **2120/LX3 MCOG** now on sale, for a limited time only, for:

$1,779.95

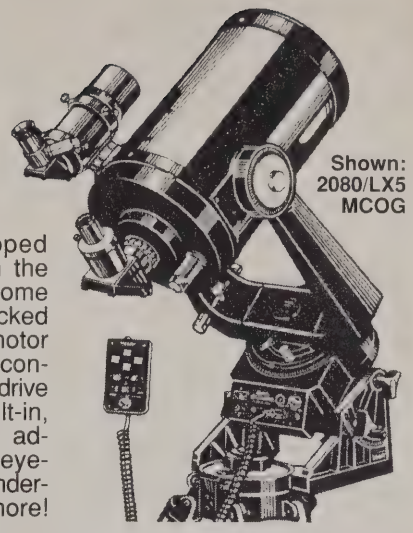
STANDARD FEATURES & FACTORY-SPECIFIED EQUIPMENT, 2120/LX3:

Complete f/10 telescope tube assembly (10" aperture, 2,500mm focal length), with certified diffraction-limited optical system; MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity (multi-layer over-coated) mirrors; ultra-smooth anti-backlash focus mechanism; large 8x50mm illuminated-reticle polar-alignment viewfinder; 1.25" visual back (eyepiece holder); 1.25" prism-type star diagonal, anti-reflection coated; Series 4000 Super Plossl eyepiece, 1.25"; rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; QUARTZ MICRO-ELECTRONIC SIDEREAL-RATE DRIVE SYSTEM and ultra-precision "LX" worm-drive gearing built into telescope drive base; POWER CONTROL PANEL (also built into drive base) WITH CONTROLS, INDICATORS and CONNECTORS for various accessory and auxiliary electronic equipment (includes input power connector; red LED indicator light; "Internal-External" drive control switch; brightness adjustment knob for *optional* illuminated-reticle guiding eyepiece; power jacks for: (1) the "Drive Control" hand-control unit ["Electronic Command Center"], (2) *optional* declination control motor, (3) *optional* LED map light, and (4) *optional* illuminated-reticle guiding eyepiece); ELECTRONIC COMMAND CENTER hand-control unit with: (a) "Quartz" (fixed) or "Manual" (variable) drive rate control switch, (b) variable (manual) drive-rate control knob (Lunar, Solar, Sidereal, etc.), (c) N-E-S-W drive correction control buttons, and coil-cord and plug for connection to telescope's Power Control Panel; AC power adapter with 25 ft. cord; 25 ft. DC power cord with automobile cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth (polar-alignment adjustments), latitude scale, bubble level and magnetic compass; ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; instruction manual; limited lifetime warranty.

2120/LX3 MCOG (List: $5,000) **$1,779.95**

FREE FREIGHT! (UPS Ground) for the LX3 shown above

NEW! Meade 8" & 10" LX5's



Shown: 2080/LX5 MCOG

The most fully-equipped Schmidt-Cassegrains on the market today! They come complete with quartz-locked microelectronic pulse motor drive, sophisticated hand control unit with photographic drive correction functions built-in, 2.00" star diagonal for advanced, premium-grade eyepieces, a giant 9x60mm finderscope, and much, much more!

STANDARD FEATURES & FACTORY-SPECIFIED EQUIP:

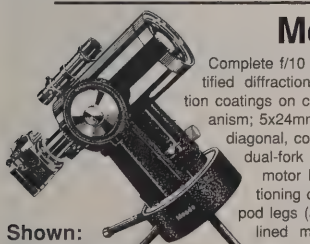
Complete f/10 telescope tube assembly (8" or 10" aperture, 2,000mm or 2,500mm focal length), with certified diffraction-limited optical system; MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity (multi-layer over-coated) mirrors; ultra-smooth anti-backlash focus mechanism; giant 9x60mm illuminated-reticle polar-alignment viewfinder with quick-disconnect mounting bracket; 2.00" mirror-type star diagonal, with 1/10 wave multi-coated mirror and adapter for 1.25" eyepieces; Series 4000 26mm Super Plossl eyepiece, 1.25" (77x or 96x); rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; DIGITAL QUARTZ MICRO-ELECTRONIC SIDEREAL-RATE PULSE-MOTOR DRIVE SYSTEM and ultra-precision "LX" worm-drive gearing built into telescope drive base; POWER CONTROL PANEL (also built into drive base) WITH CONTROLS, INDICATORS and CONNECTORS for various accessory and auxiliary electronic equipment (includes input power connector; "on/off" switch, red LED indicator light; milliammeter to show current draw; "N/S" hemisphere switch; brightness adjustment knob for *optional* illuminated-reticle guiding eyepiece; power jacks for: (1) the "Drive Control" hand-control unit ["Electronic Command Center"], (2) *optional* declination control motor, (3) *optional* electric focuser, and (4) *optional* illuminated-reticle guiding eyepiece); ELECTRONIC COMMAND CENTER hand-control unit with: (a) "Quartz" (fixed) or "Manual" (variable) drive rate control switch, (b) variable (manual) drive-rate control knob (Lunar, Solar, Sidereal, etc.), (c) correction/scanning rate switch (2x & 8x the base drive rate), (d) red LED map-light, (e) map-light control button, (f) control buttons for *optional* electric focuser, (g) N-E-S-W drive correction control buttons, and coilcord and plug for connection to telescope's Power Control Panel; AC power adapter with 25 ft. cord; DC battery-pack *(batteries not included)* with 4 ft. cord; 25 ft. DC power cord with automobile cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth (polar-alignment adjustments), latitude scale, bubble level, magnetic compass (and no-tool knob set on 8" scope only); ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; audio cassette instructions on set-up and applications; instruction manual; limited lifetime warranty.

2080/LX5 MCOG (List: $3,600) **$1,689.95**

2120/LX5 MCOG (List: $5,200) **$1,959.95**

FREE FREIGHT! (UPS Ground) for the LX5's shown above

Meade 2045 & 2045/LX3



Shown: Mod. 2045

Camera & T-Adapter for illustration purposes

Complete f/10 telescope tube assembly (4.0"A, 1,000mmF), with certified diffraction-limited optical system; high-transmission anti-reflection coatings on corrector plate; ultra-smooth anti-back-lash focus mechanism; 5x24mm coated achromatic finderscope; 1.25" prism-type star diagonal, coated; two 1.25" coated eyepieces (40x & 111x); rugged dual-fork astro mount, with frequency-controlled electric tracking motor built into base; graduated setting circles, manual positioning controls & clutches on both axes of motion; tabletop tripod legs (adjustable for latitude); dust covers; power cord; foam-lined metal-clad carrying case; instructions; limited lifetime warranty. **LX3 version has, in addition**, multi-coated corrector plate; LX3 QUARTZ MICRO-ELECTRONIC SIDEREAL RATE DRIVE SYSTEM, POWER CONTROL PANEL & DUAL DRIVE MOTORS, all built into drive base.

This unit can readily double as a high-quality terrestrial spotting scope or telephoto camera lens, making it an extremely versatile instrument. Many useful & convenient accessories and attachments are available for it.

2045 HTC (List: $1,300) ..... **CALL**

2045/LX3 MCO (List: $1,550) ..... **CALL**

Accessories for Meade Telescopes

Hand Control Unit, Mod. 36, for 2045/LX3	(List: $ 150.00)	$ 99.95
Electric Focuser, Mod. 1200, for LX3's	(List: $ 250.00)	$159.95
Electric Focuser, Mod. 1200A, for LX5's	(List: $ 230.00)	$149.95
Electric Declination Motor, Mod. 38A, for 2045/LX3	(List: $ 150.00)	$ 99.95
Electric Declination Motor, Mod. 38, for LX3's	(List: $ 150.00)	$ 99.95
Electric Declination Motor, Mod. 39, for LX5's	(List: $ 160.00)	$109.95
LensShade-DewShield, Mod. 712, for 2080	(List: $ 90.00)	$ 62.95
LensShade-DewShield, Mod. 710, for 2120	(List: $ 140.00)	$ 97.95
Accessory Tray-Shelf for Field Tripod, for 2080 or 2120	(List: $ 40.00)	$ 29.95
PIGGYBACK Bracket for camera, for 2080	(List: $ 50.00)	$ 36.95
PIGGYBACK Bracket for camera, for 2120	(List: $ 50.00)	$ 36.95
T-Ring for 35mm SLR camera (specify make)	(List: $ varies)	$ 12.95
T-Adapter for camera, Mod. 62, for all	(List: $ 50.00)	$ 36.95
Tele-Extender for eyepiece projection photography, for all	(List: $ 50.00)	$ 36.95
Off-Axis Photographic Guider System, complete, for all	(List: $ 250.00)	$174.95
Tube Balance Weight System, Mod. 1401, for 2080	(List: $ 130.00)	$ 90.95
Tube Balance Weight System, Mod. 1402, for 2120	(List: $ 140.00)	$ 97.95

Meade's Series 4000 Premium-Grade Eyepieces and Barlows in stock at low, low prices! Call for prices and recommendations . . . . . .

OUR GUARANTEE: We are solely, exclusively, professionally, a first-line, quality telescope dealership. We guarantee, unconditionally, that when you purchase a telescope or other equipment from us, you will receive all of the equipment and accessories that its manufacturer specifies for it. ***We do not*** "strip" scope kits, ***nor do we*** charge extra for the equipment, accessories or warranties intended by the manufacturers to be included with their equipment. When you buy from us, you will receive everything you pay for - you can count on it. We further guarantee, unconditionally, that all equipment sold by us is brand-new and factory-fresh. ***We do not*** take unscrupulous advantage of distant and helpless mailorder buyers; ***we do not*** buy and ***we do not*** sell ***RETURNED***, reconditioned, rebuilt, demonstrator, floor-sample, shopworn, used, loaner, rental, prototype, cosmetic defect, factory-second or otherwise imperfect goods.

NO OTHER MAIL-ORDER DEALER, TO OUR KNOWLEDGE, MAKES AND PUBLISHES SUCH A GUARANTEE! DON'T BE FOOLED; BUY ONLY FROM A 1st-CLASS, REPUTABLE DEALER.

california telescope company

CA & AK, OR FOR INFORMATION, CALL (818) 505-8424. Interbank wire transfers, DiscoverCard, MasterCard & Visa accepted - no surcharge. Most items free UPS Ground shipping in the contiguous 48 states. California shipping addresses add sales tax. Send business-size SASE for ***Free Discount Price List***; $5 ($8 foreign) check or M.O. for Catalog Package. RFQ's welcome. Prices and specifications are subject to change without notice or obligation. All sales are final.

P.O. Box 1338, Burbank, California 91507

TOLL-FREE, ORDERS ONLY, 10-4 Pacific Time, Mon-Fri:

(800) 843-4780

USED EQUIPMENT?

When buying or selling it, let the ASTRO-TRADER classified shopper help get you the results you want quickly and easily. Each biweekly issue is distributed worldwide and carries within its covers dozens of bargains on good used equipment. Why wait any longer to start using the ASTRO-TRADER? After all, these bargains won't last forever.

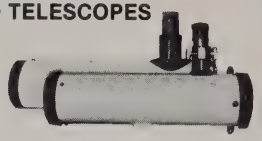
- 1 year subscription (26 issues) $12.00
- 4-line advertisement for 4 issues ..... $ 4.00 (260 char. max.. Each additional line $1.00)
- Take a $2.00 discount when you subscribe and advertise for the first time. Pay only $14.00

Call today and start using the ASTRO-TRADER with the very next issue (you will be billed later) or send your check or money order to:

THE ASTRO-TRADER
P. O. BOX 155, CASA GRANDE, AZ 85222

(602) 836-6890 5-9 p.m. Monday through Friday

4¼-INCH RICH-FIELD TELESCOPES



The finest wide-angle rich-field telescopes available. F/4.5 paraboloidal Pyrex primary and 1.5″ m.a. elliptical secondary, diffraction-limited optics, ½-wave or better. Professional mirror cells with four-vane spider, integral photo tripod mount, internally fiberglassed aluminum tube, interchangeable 25-mm f.l., Kellner 1¼″ eyepiece, dust covers.

Model 108 — Dual-thread helical focuser **$215.00**
Model 108DX — Rack & pinion focuser **$225.00**

ILLUMINATED MICROMETER RETICLE EYEPIECE

Wide-angle 25-mm Kellner, coated optics. For either 1¼″ or .965″ mounts (specify). Professional guiding and measuring glass reticle. Independent reticle focus. Bright orange LED illumination; 36-inch cord. Power pack, variable brightness control, on-off switch, batteries. Guaranteed the best and the brightest. **$69.00**

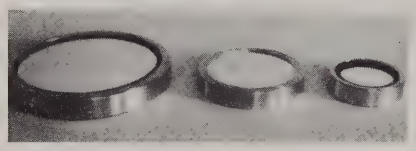
PLÖSSLS $59.00 ea.

Focal lengths: 18, 12.5, 9, and 6 mm; Wide 50° field, sharp to the edge; Multicoated for enhanced contrast; Parfocal for convenient viewing; Threaded barrels; Superior quality from one of Japan's leading optical mfrs. — for the ultimate in performance!

WRITE FOR CURRENT CATALOG. We also carry high-power and semi-rich-field telescopes; view finders; neutral-density, color, and LPB filters; camera adapters; focusing mounts; Barlows; ring mounts; dust covers; and much, much, more. VISA and MASTERCARD ACCEPTED. Illinois residents add sales tax.

CHICAGO OPTICAL AND SUPPLY CO., Box 1361, Morton Grove, IL 60053 (312) 827-4846

PRECISION SOLAR FILTERS



GLASS SOLAR FILTER - (Type 1) FULL APERTURE, made from high quality machine polished glass, TRIPLE COATED with a Nickel-Chromium alloy (same as Inconel). Mounted in a machined aluminum cell ready to attach to telescope. Why pay over 4 times as much for another brand? These filters are also available unmounted. Solar image is yellow-orange. No secondary filtering is necessary.

APERTURE (mounted)		APERTURE (unmounted)	
2.4″ $44	8″ .. $ 89	2.4″ $34	8″ .. $ 76
3.1″ 48	10″ ... 99	3.1″ 38	10″ ... 89
4″ 54	11″ .. 109	4″ 44	11″ ... 99
5″ 69	12.5″ 129	5″ 59	12.5″ 109
6″ 74	14″ .. 149	6″ 62	14″ .. 129
Binoculars up to 80mm aperture ..... $85 pr.			

GLASS SOLAR FILTER - (Type 2) Same as type 1, except stainless steel is combined with coating to provide an even more durable surface that highly resists scratching due to excessive or improper cleaning and/or handling. This coating is over 5 times as durable as an aluminized telescope mirror. Solar image is also yellow-orange.

APERTURE (mounted)		APERTURE (unmounted)	
2.4″ .... $ 59	8″ .. $119	2.4″ $45	8″ .. $ 99
3.1″ 62	10″ .. 129	3.1″ 49	10″ .. 115
4″ 72	11″ .. 149	4″ 55	11″ .. 129
5″ 92	12.5″ 169	5″ 75	12.5″ 149
6″ 99	14″ .. 189	6″ 85	14″ .. 169
Binoculars up to 80mm aperture ..... 109 pr.			

MYLAR SOLAR FILTERS - Full aperture, mounted in an aluminum cell ready to attach to telescope. We use one layer of the highest quality Mylar aluminized on both sides to our specifications for excellent optical performance. No secondary filtering is necessary. Solar image is blue-gray.

APERTURE:			
	2.4 or 3.1″ $32	10″ ..... $ 59	
	4″ 34	11″ 69	
	5″ or 6″ 38	12.5″ 89	
	8″ 49	14″ 109	
Binoculars up to 80mm aperture		$59 pr.	

All our Glass and Mylar solar filters are great for both visual and photographic use. Complete instructions are included with each filter including tips on solar photography. THOUSANDS OF OUR FILTERS ARE IN USE AROUND THE WORLD.

ORDERING INFORMATION: Solar filters are shipped free in continental U.S. when payment is included with order. Shipping extra on C.O.D. and credit card orders. Payment may be made by personal check, bank check, or money order. We accept VISA, MASTERCARD and AMERICAN EXPRESS.
PLEASE SPECIFY TELESCOPE BRAND AND/OR OUTSIDE DIAMETER MEASUREMENT OF TELESCOPE TUBE WITH ORDER.

Call or write for our free brochure on all our products. FOREIGN INQUIRIES: Please include $1 for return air mail postage. Proforma invoices available upon request.

30 DAY UNCONDITIONAL MONEY-BACK GUARANTEE ON ALL OUR PRODUCTS.

THOUSAND OAKS OPTICAL
P.O. Box 248098
Farmington, Michigan 48024
(313) 353-6825

FOR INFO CALL (201) 444-7367

CAMERA DISCOUNT CENTER

NEW JERSEY TELESCOPE HEADQUARTERS

770 ROUTE 17 NORTH
PARAMUS, NJ 07652

Open Mon.-Sat.
10:30 AM-8:00 PM

INVENTORY BLOWOUT

ENTIRE STOCK MUST BE REDUCED ON

CELESTRON · Tele Vue
BAUSCH & LOMB
Jason · Meade®

ALL TELESCOPES, BINOCULARS, EYEPIECES & ACCESSORIES

FOR PHONE ORDERS ONLY — CALL TOLL FREE

1-800-631-7111

New Jersey Residents & Information
(201) 444-7367
WE ACCEPT ALL MAJOR CREDIT CARDS
On all phone orders call
Mon.-Sat., 10:30 AM-8:00 PM

Other Pacific shipped • USA avg. $5 • complete manufacturer's packaging • Minimum shipping and handling $4.95 • Not responsible for typographical errors • Refunds within 7 days of receipt • Shipping & handling non-refundable • Some items subject to mfg. increase/decrease • Pictures for illustration purposes only

ACCESSORIES IN STOCK

TRUE BEAUTY IN BOOKS AND PRINTS

New!

EXPLORING THE SOUTHERN SKY

S. Laustsen, C. Madsen, and R. M. West

When major observatories began to spring up in the Southern Hemisphere, they revealed celestial splendors never before suspected. Now astronomers at the European Southern Observatory in the Chilean Andes have assembled this gorgeous book of the best photographs of southern objects.

Many of these images have never before been presented to the public. The 90 color plates and 147 black-and-white photographs come with extensive descriptions and commentary by the team of expert authors. The 30 reference maps, tables of plate data, indexes, and a four-foot panoramic poster of the southern Milky Way help to locate the objects and put them in their celestial context. This superb pictorial atlas serves astronomers and non-astronomers alike; a great gift for anyone! *300 pages, hardbound.*

Order 77353 *SOUTHERN SKY* . . . **$39.00**

ATLAS OF GALACTIC NEBULAE

T. Neckel and H. Vehrenberg

This first comprehensive atlas of bright nebulae was prepared by Thorsten Neckel and Hans Vehrenberg. Part 1 shows 435 objects on 425 black-and-white photographs from the Palomar Sky Survey and other sources. This first volume (three are planned) covers the sky from right ascension 0^h to 12^h north of declination $-33°$. The photographs are printed as negative halftones on 128 large, stiff pages in a sturdy loose-leaf binder. An accompanying 50-page booklet gives concise explanations and data tables in both English and German. Especially valuable to astrophotographers.

Part 2 is also available now. It covers the rest of the sky north of declination $-33°$ on 158 pages. (Part 3, now being completed, will cover the sky south of declination $-30°$. Write for availability and price.) Part 1 was reviewed in *Sky & Telescope* for July, 1986, page 34. Shipped from Germany.

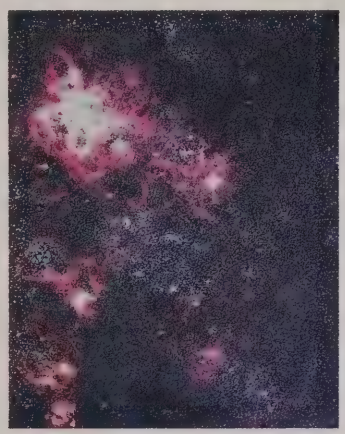
Order 41255 *NECKEL 1* . . . **$68.00**
Order S0018 *NECKEL 2* . . . **$82.00**

By Popular Demand . . .

Two New Spotlight Prints!

P0067: Mars Composite. This extremely sharp view of a summer day on Mars was recently constructed from 102 photographs taken by the Viking Mars orbiters. It may be the best overall picture of the red planet ever made. Tremendous amounts of detail are visible in the Valles Marineris canyon system, the Tharsis volcanoes, and elsewhere. This is the photograph that appeared in *Sky & Telescope* for June, 1987, page 592. A real show-stopper for your office or your living room wall!

P0068: Supernova 1987A, the brightest supernova since the invention of the telescope. Just three days after its discovery on February 24, 1987, astronomers at the European Southern Observatory made this photograph from three black-and-white images taken through color filters with the 1-meter Schmidt camera. This relatively nearby supernova has been called the biggest astronomical event of our lifetimes.



Both prints are the same size, 16 x 20 inches, custom-printed on genuine Kodak paper in our own photo lab and suitable for framing. Each comes with a detailed fact sheet. **Introductory price: $17.50 each.**

Mass. residents add 5% sales tax. Foreign add 15% for shipping. All payments must be in U. S. funds drawn on a U. S. bank, or by International Money Order. **Use the order form in the center of this issue.**

SKY PUBLISHING CORPORATION
49 Bay State Rd. ★ P. O. Box 9102
Cambridge, Mass. 02238-9102

A Meade® 10″ Schmidt-Cassegrain for the Price of an 8″!

10″ Model 2120/LX3: **$1799!** through December 31, 1987 only.

Now, for a limited time, you can buy a Meade Model 2120/LX3 10″ Schmidt-Cassegrain telescope, the instrument that started the electronic telescope revolution, for the incredibly low price of $1799—*about the price you'd expect to pay for an 8″ Schmidt-Cassegrain!*

Why? Because when we introduced the vastly successful Meade 10″ Model 2120/LX5, we were left with surplus parts and components for the 10″ Model 2120/LX3. And, in order to move these telescopes out, we're offering them at this unheard-of price. *All 2120/LX3's in this sale are brand-new, in perfect, factory-fresh condition, and all carry the Meade Limited Lifetime Warranty.*

Each 2120/LX3 is supplied complete as described below, and includes the Meade LX ("Long Exposure") worm gear drive system with quartz microelectronic timing circuitry; #36 electronic drive corrector/hand controller; multi-coated optics group; equatorial wedge and field tripod; a superb Series 4000 Super Plössl eyepiece; 8 x 50mm polar illuminated viewfinder; power cords for operation from 115v. AC home outlets or, directly, from 12v. DC auto cigarette lighter plugs; and of course the legendary Meade diffraction-limited 10″ Schmidt-Cassegrain optical system.

But act soon, because at this price we don't expect these telescopes to be in stock for long. ***This offer positively ends on December 31, 1987, and is limited to stock on hand.*** See your participating Meade dealer for prompt delivery.

SPECIFICATIONS: 10″ Meade Model 2120/LX3–Includes complete 10″ Schmidt-Cassegrain optical tube assembly, with certified diffraction-limited optical system; fork mount with LX worm gear system; quartz microelectronic sidereal drive system; power panel with outlet jacks for auxiliary electronic equipment; #36 electronic drive corrector/hand controller; 25 ft. cord for operation from 115v. AC; 25 ft. cord for operation from 12v. DC auto cigarette lighter plug; setting circles on both axes; manual slow-motion controls on both axes; eyepiece-holder (1¼″ O.D.); Series 4000 Super Plössl eyepiece; #918A diagonal prism (1¼″ O.D.); 8 x 50mm polar illuminated viewfinder; multi-coated optics group; equatorial wedge with magnetic compass, latitude scale, bubble level, and micrometric azimuth control; variable-height field tripod; deluxe latitude adjuster; dust covers; foam-lined carrying case; instruction manual; lifetime warranty.

This special offer on the Meade Model 2120/LX3 is available at participating Meade dealers between October 10, 1987, and December 31, 1987.

The Meade 10″ Model 2120/LX3 *(left)* collects **56%** more light than an 8″ Schmidt-Cassegrain. (Meade 8″ Model 2080/LX3 shown at right for comparison.)

Each 2120/LX3 includes the #36 Electronic Drive Corrector/Hand Controller, shown plugged into the 2120/LX3 power panel.

Meade® Series 4000: "Clearly the finest eyepieces available."

For about eighteen months now, we've been telling you that Meade Series 4000 eyepieces represent a new standard in professional optics for the serious amateur. Designed to an unprecedented order of sophistication, the Series 4000 oculars were, from the start, intended for the serious observer who will settle for nothing short of the very best. Meade Super Plössls include not *four* optical elements (as is the case with *all* other Plössl eyepieces on the market), but *five*, because our designers recognized that the additional element permits substantial performance improvements in corrections for chromatic aberrations and edge distortion. Similarly, Meade Super Wide and Ultra Wide Angle eyepieces set new performance standards that other eyepiece brands are still trying to match. Has the astronomical community taken notice? Indeed it has. Read a small sampling of the letters we've received on these remarkable eyepieces:

"Several hundred amateurs had the chance to test the performance of Meade Series 4000 eyepieces at the recent Astrofest Telescope Convention. Observing Jupiter with your Ultra Wide 8.8mm on a 7" f/9 Starfire refractor, the huge 84° field encompassed the entire Jovian system. The four moons were resolved as discs, perfectly round even at the extreme edge of the field. Jupiter itself presented a magnificent show with a multitude of bands, small ovals, and festoons, etched in high contrast on the planet's surface. Meade Ultra Wide Angle eyepieces are a unique design that really bring out the best in a high performance telescope."**—Roland Christen, President, Astro-Physics Corp., Rockford, Ill.**

"My experience with Meade Instruments is consistently on a higher level than with other astronomical equipment manufacturers. One Meade product is so outstanding I must comment on it. The Meade Series 4000 eyepieces are clearly the finest eyepieces available. I have owned or used just about every other commercially manufactured Plössl eyepiece, and one does not need to be a seasoned observer to immediately notice the difference." **—Michael Barnett, Westlake Village, Calif.**

"Due to annoying field curvature in my Dobsonian telescope, I returned a competitor's 24mm wide-angle eyepiece, and ordered a Meade Series 4000 Super Wide Angle 24.5mm. To my delight the Meade ocular essentially eliminated field curvature while maintaining "Plössl-like" edge to edge sharpness. I now also own the Meade Super Wide 13.8mm that has absolutely the flattest field I have ever encountered in a six-element wide-angle eyepiece. I was skeptical at first of your claims that the Series 4000 are the best eyepieces, but am now a believer." **—Richard D. Clark, Grand Junction, Colo.**

"As a former staff member at Mt. Wilson and Palomar Observatories, I have had access to some of the finest optics, including eyepieces, ever produced. When I performed some critical evaluations of the Meade Series 4000 eyepieces, it was immediately apparent that as a result of these eyepieces, the telescopes used for my tests were operating at a new visual performance level. With regard to such parameters as image contrast, definition, field flatness, and secondary spectrum, without exception these eyepieces achieved the highest level of professional precision. I find it rather difficult to comprehend there being any room for future improvement." **—Paul Roques, Williams, Ariz.**

"At a recent ocular testing party, all who wear eyeglasses preferred the Meade Series 4000 over the competition, because of better eye relief. Virtually all testers with acute color perception commented they thought the Meade oculars transmitted a sharper, more intense color image from background stars." **—Barry Smith, Chairman, Astronomy Place, Dallas, Tex.**

"Recently I had the opportunity to compare your Series 4000 eyepieces with those of the other premium brand. Comparisons were made using DFM Engineering 16" and 18" telescopes at the University of Colorado. A wide range of focal lengths were compared, but I found the Meade Series 4000's to be preferable in all cases. The Meade eyepieces had less color, gave better definition, more field of view, and more comfortable eye relief. In addition the Meade Super Wide Angle 40mm provided noticeably more field than did the competing brand's; measurements against a star field verified this fact." **—Dr. Frank Melsheimer, President, DFM Engineering, Inc., Longmont, Colo.**

Dealer Locations and Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments toll-free from anywhere in the continental U.S.A. (except Calif.): **1-800-854-7485**. From all other areas, including California, call direct (714) 556-2291.

Meade Catalog Package #87R—$3.00

Includes 4 separate catalogs and bulletins on the entire range of Meade astronomical telescopes, Series 4000 eyepieces, and accessories.

Meade Series 4000 Super Plössl, Super Wide Angle, and Ultra Wide Angle eyepieces are available in 18 focal lengths to suit any observing requirement. Barlow Lenses are available in amplifications of 2X and 2.8X.

©1987

Meade Instruments Corporation

World's Leading Manufacturer of Catadioptric Telescopes for the Serious Amateur.

1675 Toronto Way, Costa Mesa, California 92626 □ (714) 556-2291

LUMICON — WORLD CENTER FOR ASTROPHOTOGRAPHY

WHAT DO YOU NEED?

A. For Lunar and Planetary Photography:
1. Basic camera adapter or tele-extender, **$32**
2. Camera T-ring (state brand), **$12**

B. For Piggyback Photography:
1. Cable release, **$10** and piggyback mount, **$45**
2. Illuminated reticle guiding eyepiece, **$89.50**
3. 48mm DEEP-SKY filter for lens, **$119.50**

C. For Prime-Focus Photography:
1. Everything for piggyback photography
2. LUMICON EASY-GUIDER, **$170-395**
3. Dual-axis drive corrector, **$219**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

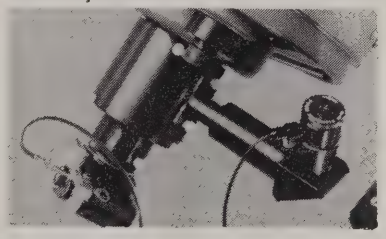
All three types of LUMICON® EASY-GUIDER (off-axis guider/Rich-Field Viewer) offer these unique features: (Patent #4448500)

- **Spectacular unvignetted Rich-Field Viewing with both 1¼" and 2" eyepieces*.**
- ½" radial adjustment and full 360° rotation make guide-stars 5 times easier to find.
- Large prism for **bright** guide-stars
- Large aperture 48mm filter compartment
- 360° camera rotation composes pictures
- Extra large achromatic focal reducing lens yields **3X shorter exposures** and edge-to-edge pinpoint star images.*

**Giant and Cassegrain EASY-GUIDERS*

GIANT EASY-GUIDER™ FOR C-11, C-14, M-2120

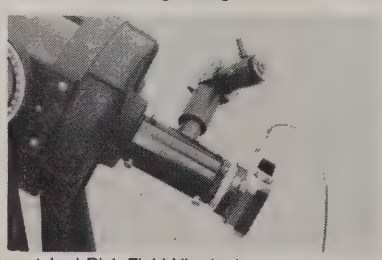
Fits both Celestron-11 and -14 and the 10" Meade 2120. 80mm telecompressor lens yields both edge-to-edge illumination and pinpoint star images at f/6. Totally unvignetted! **Superb Rich-Field Viewing!** F-ratio adjustable f/4-f/11.



Giant EASY-GUIDER Rich-Field Viewer with 80mm lens (state camera brand) **$395**
4"X5" sheet-film camera **$199**
Giant Rich-Field Viewer with 80mm lens (add photo accessories later for $179.50) **$250**
12mm LED illuminated reticle eyepiece **$89.50**
Adapter for Hasselblad **$198,** for Mamiya 645 **$96**
Adapter for Pentax 6X7 medium format **$99**

CASSEGRAIN EASY-GUIDER™ FOR C-8, MEADE 2080

Fits Celestron-8, Meade 2080, Dynamax-8. Includes 51mm lens for **both** Rich-Field Viewing and photography at f/6.2. 3X more stars, 3X shorter exposures! **No added vignetting!**



Unmatched Rich-Field Viewing!
Cassegrain EASY-GUIDER (specify camera) . **$225**
Adapter for Mamiya 645 **$99,** for Hasselblad **$185**
12mm illuminated reticle eyepiece **$89.50**
Rich-Field viewing adapter **$20**
Cassegrain Rich-Field Viewer with 51mm lens **$140**
(Photography accessories can be added later for $109)

All foreign orders add 6% ($8.00 minimum).
Calif. residents add 6% tax. Prices subject to change w/o notice.
Complete LUMICON Products catalogue set $3
LUMICON, 2111 Research Dr. #5S, Livermore, CA 94550
Call (415) 447-9570 for information or charge card orders.
Store hours: M-F 9 am - 5 pm, Sat. 11 am - 3 pm

ATTENTION ASTROPHOTOGRAPHERS

4X BRIGHTER!

The new INTENSCREEN™ camera viewing screen solves focusing and brightness problems for astrophotographers! This revolutionary aid to astrophotographers replaces your existing camera viewing screen and makes faint nebulae, galaxies, globular clusters up to 4 times brighter than with standard camera viewing screens (up to 16 times brighter for Hasselblad). Now it is EASY to see what you wish to photograph, since the bright image is like looking into a low power 50mm 2" eyepiece.

Besides making the images many times brighter, the revolutionary INTENSCREEN™ has a very fine matt surface over the full area of the camera viewing screen, making focusing much easier and more accurate. Use the LUMICON 6X critical focus telescope **$29.50** for sharpest focus. The INTENSCREEN™ is available for most 35mm and medium format cameras.

Olympus OM-1 to -4 . .	**$59.95**	Hasselblad C, 500EL .	**$129.95**
Nikon FE, FE2, FM, FA	**$59.95**	Hasselblad 500C/M . .	**$144.95**
Nikon F3 in frame	**$98.95**	Mamiya 645	**$134.95**
Contax RTS 2	**$59.95**	Pentax 6X7	**$124.95**
Pentax K	**$59.95**	Leica R4	**$74.95**

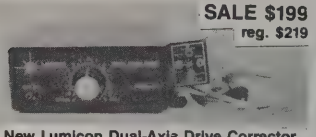
Illuminated Reticle Eyepiece

Essential for astrophotography. Lumicon 12mm illuminated reticle eyepiece has dual crosslines and red L.E.D. illumination for long life. Includes battery pack with level control.

$89.50

QUARTZ DRIVE CORRECTOR

SALE $199
reg. $219



New Lumicon Dual-Axis Drive Corrector
Allows fine corrections in right ascension and declination for astrophotography. Compact control allows "one-hand" operation. Also permits field use of your telescope off a 12V car battery. 60.00 Hz Quartz reference; 40/80 Hz variable output controls telescope drive; ± 12VDC Declination control output; Declination polarity reversing switch for equatorial mounts; both 12VDC & 110 VAC input for home or field use.
Lumicon Quartz Drive Corrector . . $199
Declination Motor (specify telescope) **$70**

NEW DIGITAL DRIVE

- Quartz crystal digital frequency generation
- Switchable lunar, solar, sidereal rates
- Normal or fast (0,120Hz) R.A. corrections
- Illum. reticle output w/brightness control
- Map, R.A., dec. setting circle illuminator output jack with brightness control
- Hi-Lo switch to conserve power
- 500mA dec motor drive w/dynamic braking

LUMICON Digital Quartz Drive $298
Dec. output: 24VDC or 110VAC, . . **add $75**

HYPERSENSITIZED FILM

ESSENTIAL FOR GOOD DEEP-SKY ASTROPHOTOS.

NEW KONICA SR-V 3200

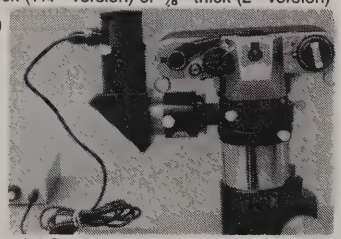
35mm film specially hypersensitized by LUMICON. B&W: Use 2415 for nebulae; great for galaxies, too. Fastest Color Slides: Use 3M 1000; Fastest Color Prints: Use Konica SR-V 3200.
Deduct 10% for 3 or more rolls.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine grain B&W, red sensitive	36	**$10.95**
Konica SR-V 3200, Super fast, Amazing Film!	24	**$13.95**
Konica SR1600, very fast, yet fine grain	24	**$12.95**
Scotch 3M 1000, Fastest slide film	12	**$12.95**
NEW! Fujichrome RD100 fine gr. color slide	24	**$11.95**
Konica SR400 fine grain high speed neg	12	**$10.95**
NEW! Konica SR400 120 size medium format	12	**$9.95**
NEW! 6415 (120 size 2415), hypersensitized	16	**$15.95**
5072, makes color slides from negs	36	**$6.95**
2415, 2X2"X.040" glass plates, unsensit.	36	**$230.00**
2415, 4X5"X.040" glass plates, unsensit.	36	**$390.00**
Bulk 2415 35mm film, unsensitized	1800	**$38.95**
4415 (4X5" 2415) 7 mil thick sheets	25	**$19.95**
D-19 B&W developer for 2415 & III a-J	1 gal	**$6.95**

NEWTONIAN EASY-GUIDER™

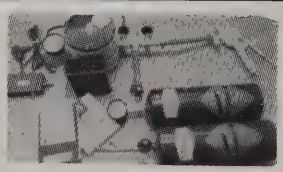
Only ½" thick (1¼" version) or ⅞" thick (2" version)

Installs in seconds into 1¼" or 2" focusing mounts. Full 1-7/8" clear aperture.



Newtonian EASY-GUIDER (specify camera type & telescope focuser, 1¼" or 2") **$169.50**
Guider for Mamiya 645 **$199,** for Hasselblad **$349**
3X Relay Diagonal **$79.50**
12mm illum. reticle eyepiece system **$89.50**
48mm DEEP-SKY Filter ($119.50) . . . . . add **$99.95**

FILM HYPERSENSITIZATION KIT †



†Patent #4473636

MODEL 1200 HYPER-KIT™

LUMICON® HYPER-KITS yield 3 to 10-fold true film speed increase in long exposures. **All films benefit.** It's completely safe and simple to do. Each HYPER-KIT includes a film sensitization chamber with all controls, a hand vacuum pump, a thermometer, a film or plate holder, a refillable cylinder of non-flammable "forming gas" for 50-100 batches, and explicit instructions.

Thermostatic temperature regulator for any HYPER-KIT . . . . . **add $59.50**

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415 users! Achieves highest possible film speeds **$295**
MODEL 300 with 2 gas cylinders **$365**
MODEL 600 HYPER-KIT is like the Model 300, but also sensitizes 126/127 and 120/220 larger format film and small glass plates **$350**
MODEL 600 with 2 gas cylinders **$420**
MODEL 1200 HYPER-KIT (see photo) is for 4"X5" plates and film up to 5"X7". Comes with 2 gas cylinders and includes a temperature controller **$595**
With electric vacuum pump, for any Model . . . . . **add $280**
35 liter cylinder of forming gas **$89.50**

LUMICON

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, compatitive prices. Both Catalogues $3

LUMICON FOR HIGH PERFORMANCE

RICH FIELD! 2.4° in a C-8?

LUMICON Rich-Field Viewer on C-8 with LUMICON 2" star diagonal and 2" eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm clear aperture for **totally unvignetted viewing** with 2" or 1¼" eyepieces. The LUMICON Rich-Field Viewer* system is available in several combinations depending on the eyepiece and field-of-view you desire (see chart below).

LUMICON Rich-Field Viewer* **$140**

Optional Eyepiece	TRUE FIELD	Price
Tele Vue 32mm Plossl	1.4°	**add $98**
LUMICON 32mm 2" Erfle†	1.9°	**add $220**
Tele Vue 32mm 2" Wide-Field†	1.9°	**add $365**
Tele Vue 40mm 2" Wide-Field†	2.4°	**add $425**

*Converts to a Cass. Easy-Guide for **$109.00**
†Includes 2" enhanced silver Star Diagonal (may not reach focus on some telescopes)

PROTECTIVE DUST COVERS

Protective plugs (left), vinyl dust covers. Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser	**4/$2**		
2" O.D. plug	**2/$2**	3½" O.D. plug	**$1.50**
1¼", 1⅞"	**3/$2**	7½"	**$8**
1½"	**2/$2**	9½", 10.4"*	**$12**
2"	**2/$2**	12½", 12⅞"*	**$15**
3½", 4½"	**$5**	16"*	**$20**
5½"	**$6**	19" (DS-16)	**$27**
*Fits Odyssey		20½" (*Odyssey-II)	**$29**

IN STOCK — IMMEDIATE SHIPMENT

MEADE MTS TELESCOPES

New modular telescopes permit customizing
6" f/5 Schmidt-Newtonian, MTS-SN6 . **$595**
Multicoated Optics Group for 6" f/5 ($120 list) **$79**
8" f/4 Schmidt Newtonian, MTS-SN8 . **$895**
8" f/10 Schmidt-Cassegrain, MTS-SC8 **$895**
Multicoated Optics Group for 8" f/4 or 8" f/10 **$99**
10" f/10 Schmidt-Cassegrain, MTS-SC10 **$1495**
Multicoated Optics Group for 10" f/10 ($200 list) **$139**

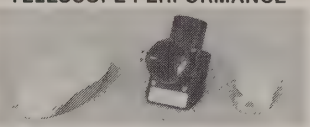
Customize with MTS Options
Electric Motor Drive (115v/60Hz) for viewing, #788 **$149**
LX3 Quartz Drive w/hand controller for photography **$495**

POWERSTAR C-8 $1685

The Powerstar C8 features a **built-in** precision digital quartz drive system to enhance the Celestron 8 optical performance. In addition to a complete 8" f/10 telescope system, the Powerstar 8 also **includes a dual-axis hand controller.** Just add the optional declination motor and be ready for astrophotography.

Powerstar C8, 8" f/10 complete telescope system ($3440 list) **$1685**
Powerstar dec. motor for astrophotography **$49**
Powerstar electric focusing motor ($150 list) **$118**
LUMICON Cassegrain EASY-GUIDER, combination off-axis guider f/6 focal compression lens and Rich-Field viewer ($345 list) **$229**

NEW! ENHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE



LUMICON 2.1" & 1.5" enhanced silver diagonal mirrors & 1¼" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"...**$29.95** 1.52"...**$34.50** 1.83"...**$39.50**
2.14"...**$49.50** 2.60"...**$65.00** 3.10"...**$89.50**
4.25"...**$149.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror) **$89.50**
2" (1.83" mirror)(see photo above) . **$145.00**

NEW ADJUSTABLE PIGGYBACK MOUNT

LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc, but is ideal for any telephoto lenses or small telescopes.

Deluxe Piggyback Mount **$45.00**
(State Telescope Type)
LUMICON 12x80mm SUPER-FINDER . $170
12x80mm right-angle Amici FINDER . $195

20mm NAGLER $340

NEW! by Tele Vue. 82° Field sharp to the edge in a revolutionary new 2" eyepiece design. 8 elements with good eye relief and no pupil aberrations. Also available in 12mm and 16mm.

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK!

Renaissance 4" f/5.5 refractor **$1395**
7.4, 10.4, 13, 17, 21, 26mm Plossl, 50° **$89**
1.8X or 2.5X Tele Vue Barlow Lens ... **$89**
32mm Plossl, widest true field in 1¼" **$109**
55mm 2" Plossl, widest possible field **$190**
15mm Wide-Field, 1¼" eyepiece, 65° **$129**
19mm Wide-Field, 1¼" eyepiece, 85° **$139**
24mm Wide-Field, "superb," 65° **$159**
32mm Wide-Field, 2" eyepiece, 65° .. **$229**
40mm Wide-Field, "awesome," 65° .. **$289**
4.8mm Nagler, 82° field **$149**
7mm Nagler, 1¼" eyepiece, 82° field . **$185**
9mm Nagler, 82° field, "the best" **$219**
11mm Nagler, 82° field, 1¼" or 2" ... **$235**
13mm Nagler, 82° field, 1¼" or 2" .. **$249**
12mm Nagler, type II, 82°, 1¼"/2" ... **$249**
16mm Nagler, Type II, 82°, 1¼"/2" ... **$299**
20mm Nagler, Type II, 82°, 2" only ... **$340**

SOLAR PROMINENCE FILTERS

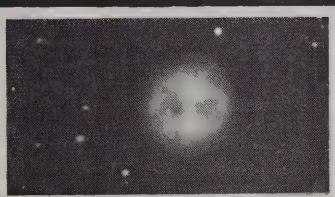
Photo by Jim Baumgardt using a 1½ Å LUMICON Filter, 12½" @f/70, 1/125 sec, 2415 LUMICON Solar Prominence Filter, 1½ Angstrom bandpass. Includes 77mm energy rejection pre-filter. (state telescope type) **$550**
3" off-axis metal mask to hold pre-filter C-8, 2080 ... **$68** C-11 ... **$88** C-14 ... **$110**
2" Adapter for C-8, Meade 2080 etc **$26**
Adapter for 1¼" or 0.96" focuser **$15**
2" adapter for C-80, C-90, C-100 refractors ... **$39.50**

STOP LIGHT POLLUTION WITH LUMICON UHC AND DEEP-SKY FILTERS

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6X contrast gain for nebulae and 1-3X contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 75-95%.

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter** or the **LUMICON UHC Filter.**



The Owl Nebula M-97 in Ursa Major. This large faint 10th magnitude planetary nebula is seen best with a LUMICON UHC Filter. (Photo by Ron Potter on hypered 2415).

LUMICON UHC FILTER™ ULTRA HIGH CONTRAST

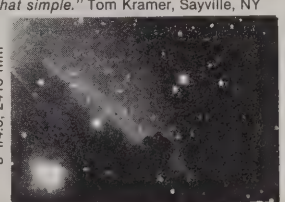
The LUMICON UHC FILTER is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm, 85-95% transmission.

	Standard	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces		**$59.50**
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces		**$79.50**
48mm LUMICON DEEP-SKY Filter (1.75" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS		**$119.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$99.50**	**$119.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)		**$299.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$79.50**	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$159.50**	**$199.50**
Set of Both premium **DEEP-SKY** and **UHC Filters** (Save 11%) **1¼" $159.50, 48mm**		**$279.50**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"**	**$89.50, 48mm**	**$189.50**
LUMICON Swan Band Comet Filter (494-518nm bandpass) **1¼"**	**$89.50, 48mm**	**$189.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm OIII lines	**1¼" $99.50,**	**48mm $199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm		**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece		**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece		**$20.00**

*Premium filters are selected best of the lot and typically have 5-10% higher transmission. Not always available. Include individually measured transmission data.

"I CAN SEE THE OWL NEBULA!"

Tom Kramer saw the Owl Nebula, M-97, for the first time using a LUMICON UHC Filter. He stated, "I had never seen M-97. Before using your filter I tried one more time and had the same result — nothing. I attached the UHC Filter and tried again. M-97 was right there, and the sky was very, very dark. I couldn't believe it! I can state with great enthusiasm that the UHC Filter should be standard equipment with any telescope sold in an urban or suburban area. It's that simple." Tom Kramer, Sayville, NY



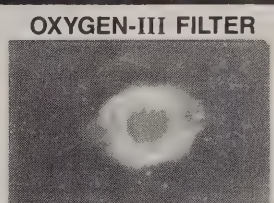
Horsehead Nebula in Orion. This faint Nebula is seen best visually with a LUMICON H-Beta Filter.

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	**$35.00**	**$29.00**
52, 55, 58, 62mm	**$45.00**	**$35.00**
67, 72, 77mm	**$52.00**	**$45.00**
82mm	**$55.00**	

OXYGEN-III FILTER



Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both OIII lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	**$99.50**	**$199.50**
Lumicon UHC	**$99.50**	**$199.50**
Lumicon Deep-Sky	**$79.50**	**$119.50**
Set UHC and Oxygen-III	**$190.00**	**$380.00**

NOTE: The Oxygen-III Filter is not a substitute, but a complement to the UHC Filter. **1 year guarantee:** You must see nebulae with the OIII filter that are **invisible** without a filter.

NEW COMET FILTERS

Veteran Comet observer and hunter Don Machholz (discoverer of Comet Machholz 1978I, 1985e and 1986e) tested the LUMICON Swan Band Comet Filter and says, *"Of seven comets I examined, five were more visible* with the filter than without it."*

Don Machholz, San Jose, CA

	1¼"	48mm	2"
Swan Band Filter	**$89.50**	**$189.50**	— —
DEEP-SKY Filter	**$79.50**	**$119.50**	**$99.50**

All foreign orders add 6% ($8 minimum)
Calif. residents add 6% tax
Prices subject to change w/o notice
Complete LUMICON Products catalogue set $3
LUMICON, 2111 Research Dr. #5S
Livermore, CA 94550
Call (415) 447-9570 for information
Store hrs: M-F 9 am - 5 pm, Sat 11 am - 3 pm

Astronomical Computing

Conducted by Roger W. Sinnott

THE TIDE AT TARAWA

THE MORNING of November 14, 1987, will not be a good time to try to land a boat on the beach of Betio Island, Tarawa Atoll, if your boat draws more than four feet of water. It will ground on the coral reef about 600 yards from the beach, forcing you to wade ashore. A configuration of the Earth, Moon, and Sun will prevent the midday high water from rising more than 3.7 feet over the reef for the next two days, just as it did 44 years ago this month during one of the most famous battles of World War II.

The amphibious landing at Tarawa was the first of its type for United States forces in the Pacific War. The first troops came in on LVT's, also known as amphtracs, which could crawl over the reef regardless of the water level. The Marines hoped to hit the beach on a flooding tide, because the succeeding assault waves would use larger Higgins boats (LCVP's and LCM's), which drew four feet of water or more when heavily loaded.*

Col. David Shoup, the assault commander, told *Time-Life* correspondent Robert Sherrod:

What worries me more than anything is that our boats may not be able to get over that coral shelf that sticks out about five hundred yards. We may have to wade in. The first waves, of course, will get in all right on the "alligators" [amphtracs], but if the Higgins boats draw too much water to get in fairly close, we'll either have to wade in with machine guns maybe shooting at us, or the amphtracs will have to run a shuttle service between the beach and the end of the shelf. We have got to calculate high tide pretty closely for the Higgins boats to make it.

The planners hoped for five feet of water over the coral reef, sufficient to float loaded LCVP's and LCM's within 150 feet of the beach. In selecting the date for the landing, it was also considered essential to allow about three hours after dawn for a naval and air bombardment, and to land the first assault troops on a rising tide about two hours before high water. Supporting logistic supplies could then come in at high water in late morning, leaving the whole afternoon for securing the beachhead.

The date chosen, November 20, 1943, seemed to meet these criteria. It provided sunrise at 6:12 a.m. and a midday high-tide level of 4.9 feet at 10:47 a.m., according to the U. S. Coast and Geodetic Survey's 1943 *Pacific Tide Tables.* (This article uses west-longitude dates and the 12-hour time zone to conform to U. S. military accounts of the battle.)

However, the tide predictions had been extrapolated from reference points as distant as Australia, Chile, and Samoa. So the task-force operation plan also included a different tide table anticipating a high water of 5.0 feet at 11:15 a.m. on D day. It came from a small group of advisers known as the "foreign legion" — Australians, Britons, and New Zealanders who had sailed among the Gilbert Islands or had lived there before the war.

These advisers also had anecdotal evidence of a phenomenon they called a

*The acronym LVT stands for "landing vehicle, tracked." LCVP is "landing craft, vehicle, personnel," and LCM is "landing craft, mechanized."

ASTRO SOFTWARE For YOUR
APPLE IIe/IIc/IIgs - IBM PC/XT/AT - C64/128
Pick the Ones YOU Want:

★ASTROCALC™★ - For What's Happening in the Sky! - Input time, date and location and ASTROCALC gives you for Sun, Moon, and all the Planets: R.A. & Dec., Alt & Az, Ecliptic Lat. & Long., Angular Size, Phase, Elongation, Orbital Elements, Rising and Setting Times, Magnitudes, Local Sidereal Time, GMT, GST, Beginning and Ending of Twilight, Julian Day Number, Equation of Time, Mean and True Anomalies, Orbit Radii, Inclination, Eccentricity, Ascending Node. Fundamentals of theory included in manual. **Thousands of Satisfied Users Worldwide** $29.95

★ASTRO-AID™★ - To Help You Get the Answers! - Integrated Software Package for Astronomical Work. In Easy-To-Use, Menu-driven Program You Get: **Time Conversions**-Julian, Gregorian, Sidrl, UT, ET, Solar; **Coordinate Conver.**-Equatorial, Eclip, Galactic, Alt-Az; **Precession; Nutation; Aberration; Parallax; Refraction; Kepler's/ Newton's Laws; Relativity; Trigonometry; Telescope Design**-Resolution, Coma, Diag. Size, Etc.; **Equinox; Solstice; Polaris Transits; Jupiter's Moon's; Solar System Data**-Sun, Moon, Planets, Satellites; **Constellations**-Names, Areas, Primary Stars. Lore; **Stars**-Nearest, Brightest, Positions, Names, Spectra. Comes complete with User's Manual $29.95

★ASTROSTELL™★ - The Constellations & Their Treasures! - All 88 constellations included plus the main deep-sky objects they contain. Provides all key information. Great way to learn all the constellations! Call up constellations by name to the screen or use random display mode to test recognition. Gives names & magnitudes of brightest stars. Shows deep-sky objects & description of them. Option to show stars only or with objects. Input date & time to get constellations visible. Classical lore given for each constellation. **For Apple or IBM only!** $29.95

★COMETWATCH™★ - All About Comets,Including Halley's! - Gives you 3 programs to calculate comet data, background on physics of comets, how to observe them & information on Halley. Calculation and on screen plot of any comet orbit with Sun & orbits of Mars, Jupiter, Saturn & Uranus for reference. Use comet data provided or input your own. For any Halley return, past or future calculates and plots path of Halley & Earth around the Sun, point by point in time $29.95

★ASTROBASE™★ - A Database for the Sky Beyond Pluto! - Astronomical database of the 300 most important deep-sky objects. User can enter hundreds of additional objects. Includes Galaxies,Open Clusters, Globular Clusters, Planetary, Emission and Dark Nebulae, Double, Variable and Special Stars, All Messier Objects and Mullaney/McCall, Best from Burnham's Celestial Handbook. Other selected objects of significance. Does searches for objects, displays or prints results. Shows objects visible for your time & location. Log information on your observations Manual includes introduction to deep-sky objects. **For Apple or IBM only!** $29.95

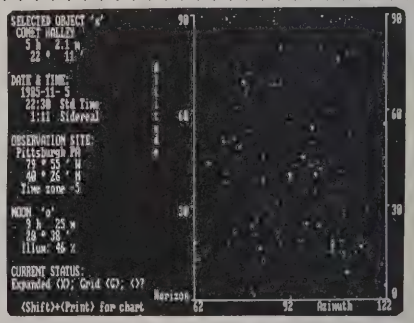
Moontracker Screen, More Detailed Maps for Suntracker

★SUNTRACKER™★ - Solar Eclipses Calculated and Displayed - Calculates conditions for a solar eclipse and displays a map with areas of visibility. Computes eclipse elements, accurate to 12 miles on the Earth's surface. Or input elements to achieve greater accuracy. With Eclipsemaster data, accuracy is to within 1 mile. Central line of the eclipse is plotted and the limits of visibility for a partial eclipse are also plotted. User can specify the percent of coverage of the Sun's diameter for the partial eclipse. Tabular data for the eclipse includes central line location, width, duration of totality and the altitude of the Sun. Complete with User's Manual $29.95

★MOONTRACKER™★ - Lunar Eclipses Computed and Displayed - Calculates the circumstances for a lunar eclipse and then displays the areas of visibility on a world map, including penumbral and umbral phases, and the rise/set lines. Tabular data is also generated including fraction coverage of moon's diameter by penumbra and umbra, position angle of shadow, longitude & latitude of point directly under moon, degrees separating the centers of the Earth & Moon shadows, angular radius of the penumbra & umbra, angular diameter of the moon. The accuracy is to within 16 miles. One mile accuracy with input from Eclipsemaster program $29.95

★ECLIPSEMASTER™★ - High Accuracy Eclipse Data! - Computes solar and lunar eclipses within 1-mile accuracy for central line, 1/20 of 1% magnitude for solar or lunar eclipses. Accurate to 3" of arc in longitude & 1" in latitude. All aspects of eclipse calculations are included: central line, local circumstances, area of visibility, duration, width of central line, finding of eclipse seasons for any year. Computes the elements of an occultation of a star or planet by the moon. $29.95

★NITEMAPPER™★ - The Day/Night Boundaries Mapped! - For any date and time calculates the Earth/Sun conditions and generates on-screen world map showing the day area in white, the night area dark, and flashing symbols where the Sun and Moon are directly overhead. Also shown are the equator, the moon rise/set line and the ecliptic, lunar nodes and perigee point projected onto the surface. The program has options to update information in real time, keep a fixed time for study, or advance conditions one hour in time every 5 minutes to watch the progress. Date and time show on screen. $29.95



Get this Skyview on Screen, or Screen Filling Expanded Mode

★ASTROFINDER™★ - Planetarium, Chart Maker

☐ **Features for Everyone - Amateur & Professional**
Simulated Skyviews on Screen, Your Date/Location; Star Charts in 4 Formats, to Selected 5th Magnitude; 30 Page Star Catalog, on Screen or Print Out; Manual with 14 Page Star Atlas, 2 Diskettes

☐ **Skyviews for Your Date, Time and Location**
1/4 of Night Sky Simulated on Screen; Center on Selected Object, Magnitude Filter; Or Choose Any Azimuth (0-360) on Your Horizon; Planning Screen Gives Alt/Az Table, Moon Status

☐ **Star Charts Printed in 4 Formats**
Skyview with Observing Conditions Given; Expanded Skyview ; Ultra-Plots (7"x10") with 1/8 Deg. Resolution; Coordinate Grids on Charts or Separately; Batch Mode, Up to 20 Charts Automatically; Linearized Transverse Mercator Projections

☐ **Auto-Retrieval of Objects to Screen, Charts**
Just Enter ID and Get Objects on Screen/Chart; All Messier Objects; Deep-Sky Objects File, Add More as You Wish; Planets & Comets Tables, LaGrangian Interpolation for Accurate Location.

Requirements: IBM or compat., DOS 2.X,3.X; 256K, 1 Drive, CGA or EGA Graphics, Any Graphics Printer (Epson FX,LX,JX,EX, IBM Proprinter, Oki 192+,193+, or equiv. for Ultra-Plots). **$69.95**

ORDER TODAY! 1-800-533-6666
9-9, Mon-Sat For Info or in PA call 412-422-6600

By phone or mail. Check, M.O., credit card (# & Expir.). Add $2 shipping ($4 overseas). PA add 6%. GIVE COMPUTER TYPE. **JOIN OUR THOUSANDS OF SATISFIED CUSTOMERS** in 50 states & over 70 countries. Fast shipment!

ZEPHYR SERVICES

1900 Murray Ave. Dept. A
Pittsburgh, PA 15217
FREE Catalog - call or write

MasterCard VISA

OUR 6th YEAR OF BUSINESS

dodging tide. On rare occasions, and only during neap periods (discussed later), the water level would remain steady for hours on end instead of rising and falling in its usual manner. The planners were well aware that the Tarawa assault fell in a neap tide period, near a last quarter Moon. But, as Adm. G. C. Dyer later wrote, "The risk was accepted along with dozens of other risks."

In the actual Tarawa assault, the first three waves in amphtracs began reaching the beach at 9:10 a.m. on November 20th. However, observers noted the water level to be only about three feet over the reef when the landing craft approached at 9:20. Thereafter, in fact for the next 48 hours, the tide level failed to rise as expected. The boats grounded at the edge of the reef and the Marines were forced to wade in, rifles over their heads, for 600 yards in the face of machine-gun fire from concrete and coconut-log pillboxes. In the words of Gen. H. M. ("Howlin' Mad") Smith: "The Japanese . . . were helped by the inexplicably low tide which held for two days."

The tide at Tarawa has been called the "laggard tide," or "the tide that failed." Commanders on the scene, and historians since, have almost unanimously regarded it as a rare and essentially unpredictable phenomenon — an act of fate. However, there are good astronomical reasons why the tide failed to rise.

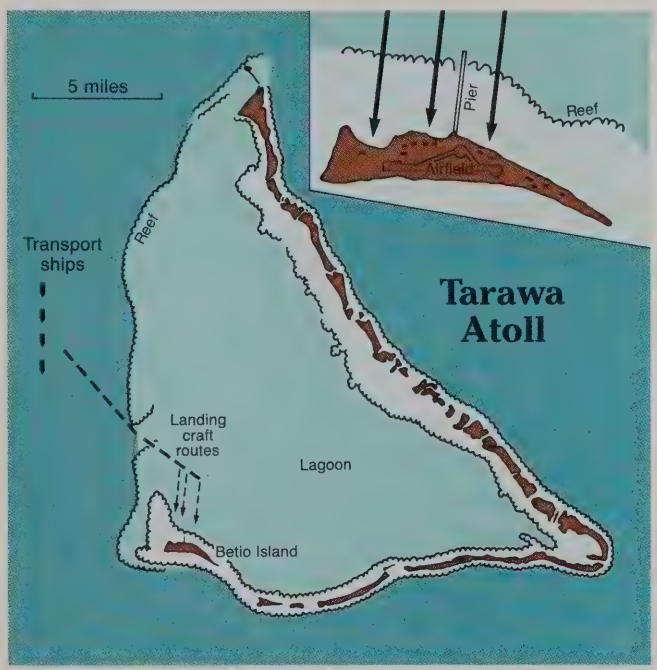
TIDE TYPES

A very thorough discussion of ocean tides may be found in Fergus Wood's *Tidal Dynamics* (Kluwer Academic Publishers, 1986). Thus, for example, *spring tides* are those of increased range occurring twice monthly as a result of the Moon being in syzygy (that is, either new or full). Mariners have known of this for thousands of years, and virtually every elementary astronomy book explains how the tide-raising forces of the Moon and Sun combine for a greater net effect.

Not so well known are *perigean tides,* also of increased range, but occurring monthly when the Moon is at perigee (nearest Earth). If the time of perigee falls near a syzygy, then perigean spring tides of extremely high range can occur. For example, on December 31, 1986, the new Moon occurred only 4 hours after lunar perigee — bringing widespread coastal flooding along the United States' eastern seaboard on January 1 and 2, 1987.

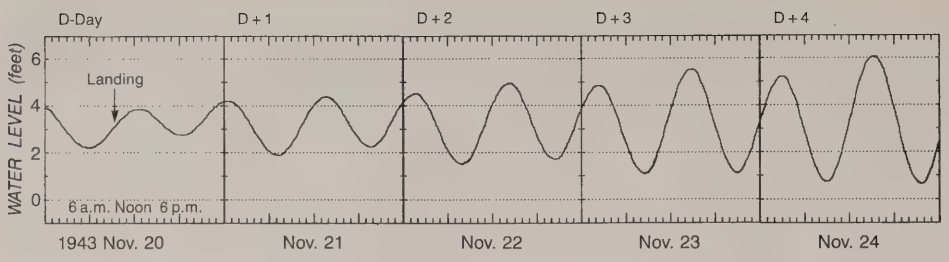
Now consider the opposite situation. *Neap tides* are those of decreased range, occurring twice a month when the Moon is near quadrature (first or last quarter). *Apogean tides,* also of reduced range, come monthly around the time of lunar apogee. If the two effects occur together, the water level fails to deviate much from the mean level. At Tarawa's reef, the mean water level is 3.3 feet.

I have calculated the lunar phases and Universal times of perigee and apogee in 1943, using the methods in Jean Meeus'



Tarawa Atoll lies in the Gilbert Islands at longitude 172° 56′ east, latitude 1° 22′ north. The assault plan called for landing craft to enter the coral-ringed lagoon from the west and then turn south for landings on three beaches of Betio Island, where Japanese forces controlled an important airfield. The 550-yard-long pier, extending out to the deep-water drop-off, is also seen in the Lovell painting below.

Combat artist Sgt. Tom Lovell painted this striking image of Tarawa: the long wade in from the edge of the reef to the shore. The momentum of the assault was lost. Low water over the reef contributed directly and indirectly to the high price, 2,292 wounded and 1,027 killed or missing, of the Marines' eventual victory. Courtesy U. S. Marine Corps Museums Art Collection.



The author's calculations, using harmonic analysis, show that the tide height was 3.1 feet at 9:20 a.m. when the landing craft began to ground on the edge of the reef. A high tide of only 3.8 feet occurred at 12:31 p.m. that day, compared to a mean water level of 3.3 feet. The tidal range grew dramatically in just a few days after the battle.

Astronomical Formulae for Calculators (Willmann-Bell, 1985 edition). On two dates that year, and only two, apogee fell within 24 hours of quadrature:

F. Q.	Apr. 12, 15^h	L. Q.	Nov. 19, 23^h
Apogee	Apr. 12, 22^h	Apogee	Nov. 19, 10^h

Thus, the landing at Tarawa was scheduled for one of only two occasions in 1943 when apogean neap tides could occur.

There have been many reports, books, and articles about Tarawa. Virtually all of the authors discuss neap tides, but no postmortem I've seen mentions the lunar apogee of November 19th and its effect of reducing the tidal range.

HARMONIC ANALYSIS

I have used two independent methods to recompute the tide at Tarawa, both based on harmonic analysis. The first considers Tarawa as a subordinate station and derives its results from those of the reference station at Kwajalein, another atoll lying 600 miles to the northwest. The "station constants" for Kwajalein, available from the National Ocean Service, are based on extensive observations in 1946-49. They give the amplitudes and phases of 18 different harmonic constituents.

The periods of these constituents are simple combinations of five fundamental periods: the tropical month of 27.321582 solar days, the tropical year of 365.2422 days, the revolution of the lunar perigee in 8.85 years, regression of the lunar nodes in 18.61 years, and slow advance of the solar perigee over 209 centuries.

Because Kwajalein and Tarawa have different mean levels, ranges, and times of high and low water, I derived the following linear correction:

$$y = 3.3 + 1.25\,(x - 3.0),$$

where x is the tide height at Kwajalein in feet, and y is the tide height expected 20 minutes later at Tarawa.

For an independent check, I located a set of observations made by the U. S. Navy at Tarawa itself from December, 1943, through the following April. Using the methods and equations given in the *Manual of Harmonic Analysis and Prediction of Tides,* Special Publication No. 98 of the U. S. Coast and Geodetic Survey (now the National Ocean Service), I was able to employ only 11 harmonic constituents. But the station constants derived in this case apply to Tarawa directly with no further correction.

The two methods agree within 2 inches as to the tide height at Tarawa, and within 7 minutes on the times of high and low water. In fact, from 9 a.m. until 10 p.m. on D day the water hovered within 6 inches of its mean level, 3.3 feet. It was an apogean neap tide of reduced range, but technically neither a dodging nor a vanishing tide, as the chart at left shows.

Later reports also check out: correspondent Sherrod's descriptions of the coral flats during the low waters early on D+1 and D+2; resumption of "normal" high waters of five feet or more beginning on D+2; and a high water covering the entire beach and washing against the seawall during an inspection tour by Gen. J. C. Smith and Gen. H. M. Smith on the afternoon of D+4.

COMPARISON TO NOVEMBER, 1987

On November 19, 1943, the last quarter Moon occurred 13 hours after lunar apogee, with the Moon at declination +14° and the Sun at −19°. On November 13, 1987, the last quarter Moon will occur 21 hours after lunar apogee, with the Moon at +18° and the Sun at −18°.

As a result, observers in southern California will see tides in the Los Angeles harbor and at San Diego reduced to the range of about 8 inches during daylight hours on November 13, 1987, compared to a mean range of 4 feet, and to the range of over 7 feet observable a week earlier or a week later.

Few people will be able to travel to Tarawa, now a part of the Republic of Kiribati. But if they do, they'll see the midday high water "fail to rise" on November 13 and 14, 1987, in a manner very similar to the apogean neap tide that occurred there 44 years ago.

DONALD W. OLSON
Dept. of Physics
Southwest Texas State University
San Marcos, Tex. 78666

PROGRAM NOTES

The harmonic-analysis program is too lengthy to give here, but that for lunar apogee and perigee is on the facing page. It asks for a Julian Day number, finds the preceding lunar perigee, and then gives succeeding apogees and perigees until interrupted.

For example, this month the program predicts an apogee of 404,416 km on the Julian date 244 7112.24 (that is, 18^h UT on the 12th), and a perigee of 366,810 km on 244 7124.11 (15^h on the 24th), agreeing well with the values on page 515 of this issue. The program's times are good within one hour, and distances within 30 km, for any date since about the year 1500. Its expressions are adapted from the more extensive ones in the Meeus book cited in the text.

SPECIAL OPTICS
MANUFACTURE AND DESIGN

A well-established and growing manufacturer of precision optical systems and components for the laser industry and research community is seeking an

OPTICIAN-POLISHER

The ideal candidate must have extensive experience in the polishing and interferometric testing of plano and spherical optics to typical tolerances of 1/10 surface accuracy and 20-10 surface quality, and must possess the ability to perform a wide variety of critical blocking and grinding operations.

- Salary commensurate with experience
- Excellent benefits package
- Relocation assistance provided

Send resume to: Bob Stewart or call at (201) 785-4015

Box 163, Little Falls, New Jersey 07424

```
10 REM   LUNAR PERIGEE AND APOGEE
11 INPUT "STARTING JD";J0
12 P0=2415024.89:  M0=27.554551
13 J0=P0+M0*INT((J0-P0)/M0)
14 GOSUB 40     :REM GET CONSTANTS
15 FOR I=1 TO 3: P1=0: P2=0
16 T=(J0-2415020)/36525: T2=T*T
17 M1=R*(296.105+R1*T+0.009192*T2)
18 D=R*(350.737+R2*T-0.001436*T2)
19 M=R*(358.476+R3*T-0.000150*T2)
20 F=R*(11.251+R4*T-0.003211*T2)
21 E=1-0.002495*T-0.00000752*T2
22 FOR J=1 TO 30
23 A(J)=A1(J)*E^C0(J)
24 B(J)=C1(J)*M1+C2(J)*D+C3(J)*M
25 B(J)=B(J)+C4(J)*F
26 P1=P1+A(J)*SIN(B(J))*R(J)
27 P2=P2+A(J)*COS(B(J))*R(J)*R(J)
28 NEXT J
29 J0=J0-(36525/R)*(P1/P2)
30 NEXT I
31 P=950724
32 FOR J=1 TO 30:
33 P=P+A(J)*COS(B(J))
34 NEXT J
35 K=6378.14/SIN(R*P*0.000001)
36 K=INT(K+0.5): PA$="PERIGEE   "
37 IF P2<0 THEN PA$="APOGEE    "
38 PRINT PA$;K;" KM    JD ";J0
39 J0=J0+13.78: GOTO 15
40 REM      CONSTANTS
41 DIM A(30),B(30),R(30),A1(30)
42 DIM C0(30),C1(30),C2(30),C3(30)
43 DIM C4(30): R=3.1415926536/180
44 R1=477198.8491: R2=445267.1142
45 R3=35999.0498:  R4=483202.0251
46 FOR J=1 TO 30
47 READ A1(J),C0(J),C1(J)
48 READ C2(J),C3(J),C4(J)
49 R(J)=C1(J)*R1+C2(J)*R2
50 R(J)=R(J)+C3(J)*R3+C4(J)*R4
51 NEXT J
52 RETURN
53 DATA 51818,0,1,0,0,0
54 DATA 9531,0,-1,2,0,0
55 DATA 7843,0,0,2,0,0
56 DATA 2824,0,2,0,0,0
57 DATA 857,0,1,2,0,0
58 DATA 533,1,0,2,-1,0
59 DATA 401,1,-1,2,-1,0
60 DATA 320,1,1,0,-1,0
61 DATA -271,0,0,1,0,0
62 DATA -264,1,1,0,1,0
63 DATA -198,0,-1,0,0,2
64 DATA 173,0,3,0,0,0
65 DATA 167,0,-1,4,0,0
66 DATA -111,1,0,0,1,0
67 DATA 103,0,-2,4,0,0
68 DATA -84,0,2,-2,0,0
69 DATA -83,1,0,2,1,0
70 DATA 79,0,2,2,0,0
71 DATA 72,0,0,4,0,0
72 DATA 64,1,1,2,-1,0
73 DATA -63,1,-1,2,1,0
74 DATA 41,1,0,1,1,0
75 DATA 35,1,2,0,-1,0
76 DATA -33,0,3,-2,0,0
77 DATA -30,0,1,1,0,0
78 DATA -29,0,0,-2,0,2
79 DATA -29,1,2,0,1,0
80 DATA 26,2,0,2,-2,0
81 DATA -23,0,1,-2,0,2
82 DATA 19,1,-1,4,-1,0
```

Electronic News Service

Computer owners with access to modems can obtain quick news from *Sky & Telescope* of comet and nova discoveries, and also program listings from the Astronomical Computing department. After you join CompuServe (through a local Radio Shack or other computer dealer), log on and at any ! prompt type GO HOM-22. Then you select the DL9 data base and type READ SKYTEL.TXT in order to receive this service.

Review Corner

Deep Space, David Chandler Co., P. O. Box 309, La Verne, Calif. 91750. $59 on two 5¼-inch disks for IBM PC computers. Includes 3-D viewer kit, "The Night Sky" planisphere, and the book *Exploring the Night Sky with Binoculars.*

THE NIGHT SKY appears flat, and so do our maps of it — or at least they did until now. This very new program shows the universe as you would see it if your eyes were separated by a sizable fraction of a light-year instead of two inches. Nearby objects float in front of more distant stars.

In its two-dimensional (2-D) mode, Deep Space generates computer star charts on screen or on paper. You can view the entire visible sky (as in a planisphere) or a small area at a desired scale. You have a choice of equatorial, ecliptic, or galactic coordinates, and the data base contains 18,000 stars to magnitude 7.2.

In 3-D mode, the program prints two charts side by side with the star images offset as if they were viewed from points in space a few tenths of a light-year apart. You can select the length of this baseline. As seen through the accompanying stereo viewer (an easily assembled device of plywood and mirrors), nearby stars pop off the page and seem to stand a few inches above the paper, while more distant stars sit farther away. It's startling to see for the first time.

Even more startling is the path of a comet as it stands out in front of a star field. With the stars set at an infinite distance, the comet's orbit hovers in space like an unsupported arc of black thread. If you wish, a tail 0.1 astronomical unit long assists in visualizing the comet's distance and orientation. Comet Bradfield, 1987s, loops over Centaurus and Lupus before leaping across Scorpius and toward your left ear. You can generate a finder chart for any comet whose elements you know (a dozen are included for starters).

Additional options let you print a detailed ephemeris or view the comet's orbit from any vantage point in space. And, in an entirely different vein, the program can generate a chart of the planets' elongations from the Sun for the year.

Instructions are clear and the printouts clean and nicely laid out. At present the planets are not plotted on the maps, but they and the bright asteroids are slated for inclusion within the next few months. A Macintosh version is planned for 1988.

JOHN MOSLEY
Griffith Observatory
2800 E. Observatory Rd.
Los Angeles, Calif. 90027

The Amateur Astronomer's Field Guide to Deep Sky Observing

By Tom Lorenzin
With Tim Sechler

The new book that's been called ***"the perfect field companion."*** Meet the challenge of seeing over one thousand deep sky objects with the only work of its kind available on the market today.

- ► Suitable for beginners as well as advanced amateurs
- ► Epoch 2000, Mag. 6.0 (naked-eye) Sky Atlas included
- ► Database of over twelve hundred deep sky objects, down to Dec. −40°
- ► Guide to the selection and use of observing tools
- ► Large 11″×15″ durable-cover format
- ► Lay-flat design for easy use at the telescope
- ► Dew-resistant pages

Pre-publication sale price
Only $29.95
Add $2.50 for shipping and handling
Regular list price of $39.95 effective January 1, 1988

Order Now
Call (704) 664-1901
Visa, MasterCharge or Send check or money order (Before December 15 for holiday delivery)
Write for our illustrated brochure. It's FREE.

1000+
P.O. Box 700-S
Davidson, NC 28036

My town, Our Planetarium (1)

Imagine a New Space with the GOTO SPACE SIMULATOR.

Next to Tokyo, the city of Yokohama with its population of 3 million is Japan's largest city.

Today, the city is speeding ahead into the 21st Century. As it does so, the YOKOHAMA SCIENCE CENTER, which fosters the youth who will create the technology of the future, was completed. The center covers space science and natural science, and gives information about the city of Yokohama. There is a computer and video texts, and for the first time children will actually be able to use them to study. There will also be all sorts of displays. The Space Theater is one of the main installations at the Science Center.

The dome is 23 meters in diameter and has seating for 300. This is the first time in Japan a 30° tilted screen has been employed. The GOTO SPACE SIMULATOR GSS system is installed in this space theater.

- Goto Space Simulator GSS provides a new concept in Planetariums.

(1) The world's first space simulator with perfect free-axis movements can be set on any rotating axis.

(2) Digitally controlled Projector Group for Planets.
  - Can display all planet positions from the past and into the future with up-to-the-minute accuracy.
  - Can project planetary movement at any point in the solar system and the surrounding vicinity.

(3) It, of course, has all the same functions as ordinary planetariums.

(4) Can exhibit 25,000 stars at color temperature 5,600° Kelvin, down to apparent visual magnitude 7.4.

- Use of the 30° inclined dome with a 23-meter diameter. Abundant images give the feeling of being in the space that is spread out before you.
- The space sound system, with a maximum output of 110 dB, has a large sub-woofer and can freely move acoustic images in a plurality of channels within the dome. This is done with a matrix control using a computer system.
- The multi-image system, consisting of a highly efficient group of 60 projectors, includes special 70mm, 2kw slide projectors. It can create dome images which have never before been experienced.
- The lighting effect system can change the screen surface to any color.

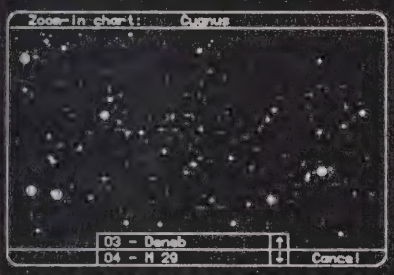
Our company makes various types of planetariums, ranging from a small type (3 meters in diameter) for use in schools to a large-scale type 30 meters in diameter.

GOTO OPTICAL MFG. CO.
4-16 YAZAKICHO, FUCHU-SHI, TOKYO 183, JAPAN
TEL: 0423 (62) 5311
TLX: 2832421 GOTOPTJ
FAX: 0423 (61) 9571

ANDROMEDA

A real planetarium, with on-screen movement!

As many as 25 charts per second!



Zoom-in charts show star names, nebulae, clusters and galaxies, even supernova SN 1987A.

Other programs take minutes to draw a sky chart; ANDROMEDA shows several per second. View the solar system and ecliptic; zoom-in on Messier objects, many NGC's and 9600 stars. Charts are user definable.

Full version shows precession of equinox, sidereal and solar days as well as heliocentric-geocentric animated views of solar system.

ANDROMEDA is easy to use, and can make full use of the mouse. It won Minister of Education Award for best educational software for 1986.
Requires Apple IIe or Apple IIGS, 128K, two 5-1/2" drives.

DEMO	**$9.95**
PLANETARIUM PACKAGE constellations, planets, zoom-ins	**$69.95**
EDUCATIONAL PACKAGE full-blown version	**$119.95**
UPGRADE KIT converts the planetarium package to full version	**$59.95**

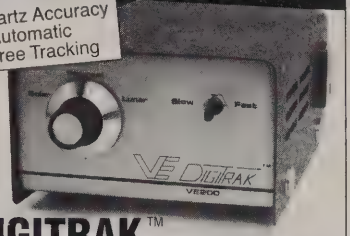
VISA and MASTERCARD accepted. Foreign payment must be in U.S. funds. Order outside U.S. and Canada add 15%. Quebec residents add 9% sales tax. Apple II is a trademark of Apple Computer, Inc.

Cosmo-Logique
P.O. Box 105, 398 Pilon, Dorion-Vaudreuil
Québec, Canada, J7V 5W1

ASTROPHOTOGRAPHERS!

LOWEST PRICE!
Digital Quartz Accuracy For Automatic Worry-Free Tracking

Portable Power For Field Use Of Your Telescope.

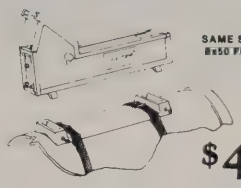


VE DIGITRAK™ DRIVE CORRECTORS

Call or Write for **BROCHURE**

FREE VOGEL ENTERPRISES, INC.
P.O. Box 3717, Oak Park, IL 60303
1-800-457-TRAK (IL: 312-456-TRAK)

Telrads®



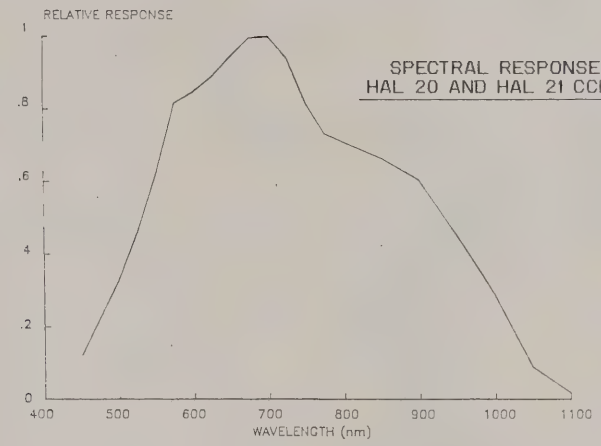
VISA • MC CHECK

$44.50

Ingenious finder easily and quickly locates any reference point in the sky, without setting circles or polar alignment and images are always erect!

astro•tech
101 WEST MAIN ■ P.O. BOX 2001
ARDMORE, OKLAHOMA 73402
405/226-3074

30 Day Money-Back Guarantee!



SPECTRAL RESPONSE CURVE OF HAL 20 AND HAL 21 CCD DETECTORS

HARDWARE

CCD CAMERAS:

All CCD cameras include selected 572 x 485 Sanyo CCD chip, power supply, integration board, 24-bit digital I/O card and cables.
Camera Control Software is free with all cameras and includes assembly and C routines. (Source code and executable code.)

Purchase orders from institutions accepted.
Substantial discounts available if you have purchased HAL 8 previously.
Special Discounts for Astronomy Clubs.

HAL 20

Uncooled integrating CCD camera. Maximum exposure is dependent on the ambient temperature. Intended for use alone or with image intensifiers. Price $3,500.

HAL 21 PC35

Thermoelectrically cooled (-35°C) CCD chip mounted in a permanent vacuum housing.
Miniature remote camera head is intended for use alone or with very low gain image intensifiers. Price $6,200.

HAL 21 PC65

Thermoelectrically cooled (-65°C) CCD chip mounted in a permanent vacuum housing.
Miniature remote camera head is intended for very long exposures. Price $8,500.

PERIPHERALS FOR CCD CAMERAS

NEW 640 x 480 x 8 bits real-time digitizer with video display card and 16 million colors. 1 meg RAM for images. Complete executable acquisition and enhancement software includes seeing correction.

ORDERING INFORMATION:
C.O.D. and info. call: 619-698-9174. Demo Disks: $5.00. State computer brand. Astro Link Catalog: $2. Foreign (except Canada) add $10 shipping for software & $75 state department licensing fee for intensifiers. All foreign shipping of CCD's and intensifiers collect via Emery worldwide. Calif. res. add 6% tax. Prices subject to change without notice.

IMAGE INTENSIFIERS:

HAL 4 18-mm, 40,000-gain, first-generation, 3-stage intensifier. Photocathode is S20 extended red. W/housing, Plossl eyepiece, and 90-mm f/1.2 lens. **$1,700.**

HAL 5 Video adapter for HAL 4 and HAL 6. **$255.**

HAL 6 25-mm, 60,000-gain, first-generation, 3-stage tube. W/housing and eyepiece. **$1,500.**

HAL 30 25-mm brand-new, above-specs, 55,000-gain, second-generation tube with gain control. S20 extended red. 1-year warranty. **$2,195.**

HAL 31 Housing for Hal 30 and HAL 32 with gain control, removable eyepiece or video adapter with T adapter in front.
W/Plossl eyepiece **$395.**
W/video adapter & relay lens **$540.**

HAL 32 25-mm, 30,000-gain, second-generation tube. **$875.**

Adventures in Video Astronomy video tape, 1 hour long. Includes telescopic and wide-angle views of the sky. All done with our intensifiers and CCD cameras, and includes enhancing demonstrations. **$49.**

SOFTWARE

All software programs 50% off for November.

SAL 1: INDOOR ASTRONOMY FOR APPLE II+, IIe, IIc, C64, & C128, IBM PC & compatibles. The Ultimate Computer Sky Generator program.
See faint stars including 6th mag. & 2,000 deep-sky objects, 24 deep-sky symbols at low magnifications and large deep-sky object simulations at over 50 magnification. One-key printouts and beautiful Hi-Res images are a must for home, school, or the observatory. IBM PC version needs CGA or EGA and 256K RAM. APPLE version needs 64K. **$59.**

Get SAL 1, SAL 3, SAL 4 and SAL 6 for C64 or C128. **$79.**

SAL 3: ASTRO LINK INFO. SYSTEM for C64: Detailed Astro deep-sky data base. **$29.**

SAL 4: TOOL BOX & GRAPHICS Editor for C64 Indoor Astronomy. **$29.**

SAL 6: MESSIER CATALOG for C64: 220 charts and digitized images of Messier objects. **$29.**

ASTRO LINK, P. O. BOX 1978, SPRING VALLEY, CA 92077

ORION TELESCOPE CENTER

FREE CATALOG

Call Toll Free!

800-447-1001 In Calif. 800-443-1001

Telescopes & Accessories

Your #1 Source for Major Brands

Call or write for information and competitive prices. This ad shows only a small selection of our quality Orion brand products; we stock hundreds of other name-brand telescopes, binoculars, and accessories.

Meade
CELESTRON
TeleVue
ORION

Orion Works For You!

Our exceptional service and competitive prices make Orion the place to shop for all your needs. We back up our selection and prices with free phone calls and our money-back guarantee of satisfaction.

Warning to Penny Pinchers!

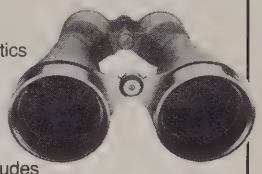
Please don't buy from one of the big camera discount warehouses or a "PO Box" operation just to save a few percent. Can you return for a full refund including shipping? Will they charge your credit card even when the product has not yet been shipped? Is there a toll-free number to call with questions (not just an "order line")? Do they know and use telescopes, or just sell boxes? Whether you buy from one of our retail stores or our catalog department, we're committed to offering the best service available, and have very competitive prices due to our high volume. We hope you will support our efforts, and we pledge to do everything in our power to make you happy.

Our 100% Satisfaction Guarantee

If you are not completely satisfied with your mail-order purchase from this ad for any reason, just return it in new condition within 30 days after delivery for a prompt refund.

New! Orion Enhanced™ Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars.



Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness. Includes lens caps, case, straps, tripod mounting bracket.

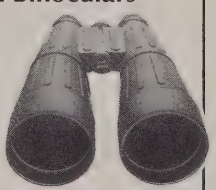
Enhanced 10x70 Binoculars
Offer performance superior to standard 'fully coated' 11x80 models. #9501 **$249** (4.25)

Enhanced 11x80 Binoculars Exceed the performance of major brand competitive models. #9502 **$299** (5.30)

Affordable Deep Sky Binoculars
These well-made fully coated binoculars with BK-7 prisms offer impressive views of nebulas, galaxies and other deep-sky objects. Each include deluxe hard case, lens caps, straps, tripod mounting bracket. **SALE**

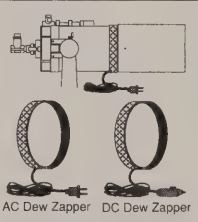
10x70 Binocular #9505 **$179** (4.25)
11x80 Binocular #9506 **$229** (5.30)

Little Giant™ 9x63 Fully Multi-Coated Roof Prism Binoculars



Our Little Giants aren't just 'Coated Optics' or 'Fully Coated', they're *Fully Multi-Coated*, so every objective lens and prism surface is multi-layer coated for the absolute peak of optical performance. 6° field of view. Light weight (2.8 lbs.). Includes lens caps, case and straps. #9500 **$169** (3.29)

The Dew Zapper



AC Dew Zapper DC Dew Zapper

Applies warmth to the perimeter of the corrector plate. Ideal for use at home or in the field. Works alone or along with any dew cap. For Meade or Celestron 8" Schmidt Cassegrains.

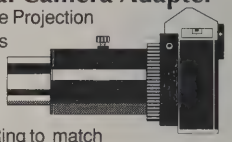
12 volt DC Dew Zapper Plugs into cigarette lighter receptacle. #3503 **$33.95** (1.60)

110 volt AC Dew Zapper Plugs into household 110 volt wall outlet. #3504 **$33.95** (1.60)

New Orion Brand Accessories. Save money without compromising quality.

These accessories are of the same grade as offered by major telescope manufacturers. Orion buys direct, so you save money. No middleman's markup.

Orion Universal Camera Adapter



Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors with 1.25" eyepiece holders. Use with T-Ring to match your 35mm camera. #5264 **$29.95** (1.60)

Orion Tele-Extender

Eyepiece Projection Tube for high powered photography through Meade or Celestron Schmidt-Cassegrain telescopes. #5125 **$27.95** (1.60)

Orion T-Adapter

Couple your 35mm camera to a Meade or Celestron Schmidt-Cassegrain. Use with T-ring to match your 35mm camera. #5116 **$27.95** (1.60)

Orion Off-Axis Guider Body

Use with any 1.25" Illuminated Reticle Eyepiece to accurately track a guide star during long exposure astrophotography. For Celestron or Meade Schmidt-Cassegrains. #5144 **SALE $49.95** (1.79)

Orion Rich Field Adapter

Get four times brighter image and twice the field of view when used with 20mm-32mm 1.25" eyepieces. #5128 **$88** (2.09)

Telecompressor Lens

Get 4 times the brightness and cut your exposure time in half while doubling your field of view. The Orion telecompressor lens works with Meade and Celestron 8"-10"-11" Schmidt-Cassegrains #5141 **$34.95** (1.60)

Extension Tube

Needed for proper focus when using the a telecompressor and an off-axis guider. #5123 **$19.95** (1.60)

Serving Amateur Astronomers Worldwide Since 1975

Silicon Valley Retail Store Now Open
10555 South DeAnza Blvd., Cupertino, CA (408) 255-8770

Santa Cruz, Calif. Retail Store & Catalog Headquarters
421 Soquel Avenue at Ocean Street. (408) 458-9090

America's Largest Telescope Dealer

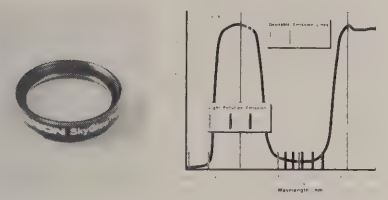
ORION TELESCOPE CENTER

421 Soquel Ave, Dept. N, P.O. Box 1158, Santa Cruz, CA 95061

America's #1 Source for Telescopes and Binoculars

ORION
TELESCOPE CENTER

New! Orion SkyGlow™ Enhanced Light Pollution Filter



Most street lights emit light at a particular narrow wavelength. By blocking these wavelengths and passing the rest of the visible spectrum, contrast is dramatically improved. The Orion SkyGlow Filter allows maximum transmission of the important wavelengths of Hydrogen Alpha, Hydrogen Beta, and Doubly Ionized Oxygen—the light 'bands' most commonly emitted by Nebulas. It features better blocking of mercury vapor light and higher transmission at the critical Hydrogen Alpha and Hydrogen Beta frequencies than many competing models.
Designed for visual observing with any telescope, it threads into any standard 1.25" eyepiece. Includes handy storage case.

#5660 **$59** (1.60)

Orion Observer Series Eyepieces

Manufactured to strict tolerances. Chrome-plated brass barrels, fully coated, threaded for filters.

Orthoscopics 1.25" **SALE $39** (1.60)
5mm #8471 9mm #8474
7mm #8472 12.5mm #8475

Kellners 1.25" **SALE $25** (1.60)
18mm #8466 25mm #8467 40mm #8469

20mm Erfle1.25" #8485 **SALE $49** (1.60)

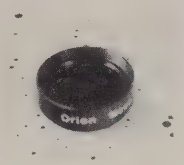
Orthoscopics .965" **$39.95**(1.60)
5mm #8440 7mm #8442 9mm #8444
12.5mm #8446

Kellners .965" **$24.95** (1.60)
6mm #8450 9mm #8452 12mm #8454
18mm #8456 25mm #8458 40mm AH #8460

Fully Coated Barlow Lenses
1.25" 2x Barlow #8744 **SALE $31**(1.60)
.965" 2x Barlow Lens #8742 **$26.95** (1.60)

Precision Erecting Prisms
1.25" Erecting Prism #8757 **$39.95** (1.60)
.965" Erecting Prism #8756 **$35.95** (1.60)

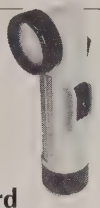
New! Orion Moon Filter



Enjoy the moon's detail without spoiling your night vision. Our new Moon Filter will cut 87% of the light from the moon. Reduces glare of full or gibbous Moon by uniformly reducing light transmitted over the entire spectrum.

For 1.25" Eyepieces #5662 **$14.95** (0.95)
For .965" Eyepieces #5664 **$14.95** (0.95)

Astronomer's Flashlight



Made of unbreakable plastic. Has special night-vision red filter and a diffusion lens for even illumination. Includes belt clip, extra bulb.

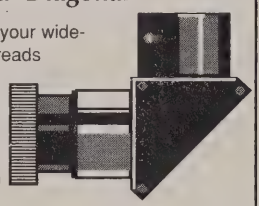
#5701**$8.95**(1.60)

Rubber Eyeguard

Soft rubber eyeguard stretches to fit most 1.25" eyepieces. Cuts off annoying ambient light and helps you position your eye at a comfortable distance from the eyepiece.

#7405 **$2.95** (.95)

2" Mirror Star Diagonal



Get the most from your wide-field eyepieces; threads onto Celestron or Meade 4"-8"-10"-11" Schmidt-Cassegrains.

#8767 **$89** (2.09)

2"-1.25" Adapter

Use 1.25" eyepiece in a 2" diagonal or 2" focuser.

#8768 **$12.95** (1.60)

Orion 2" Eyepieces

Excellent quality wide-field eyepieces. Get maximum field width from our new Erfle for impressive views through your telescope. Our 2" Plössl will amaze you! Both Orion 2" eyepieces are multi-coated for great contrast and clarity.

50mm Plössl #8490 **$89** (2.39)
32mm Erfle #8492 **$99** (2.39)

9mm Orthoscopic Illuminated Reticle Eyepiece

Our new improved illuminated reticle eyepiece is an excellent choice for astrophoto guiding or polar alignment. Self contained battery and illuminator eliminate cables and control boxes. Complete brightness control with the integral rheostat. The 4-element Orthoscopic design provides very sharp images. Barrel is internally blackened to reduce stray reflections.

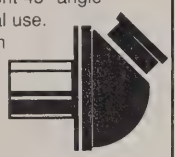
#8488 **$99** (1.60)

Illuminated Reticle Eyepiece

Double crossline reticle in a 12mm Kellner 1.25" Ocular. Plugs in to most Telescope control panels.

#8482 **$59** (1.79)

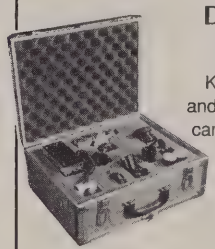
45° Correcting Diagonal



Correct images and convenient 45° angle viewing. Perfect for terrestrial use. Eliminates the need to crouch behind scope as with standard "straight-through" porro prisms.

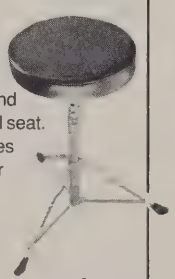
#8765 **$56** (1.79)

Deluxe Metal-Clad Accessory Case



Keep your accessories safe and clean. Diced foam inserts can be tailored to your needs.
#5920 (16"x12"x6 1/2")
$49.95 (3.85)
#5921 (19 1/2"x12"x6 1/2")
$59.95 (4.95)

Observer's Chair



Perfect for all types of telescopic viewing. It has six adjustable height positions from 19" to 24" and a very comfortable padded swivel seat. The legs fold and the seat removes from the chrome-plated frame, for easy storage. Comfortable and very affordable. Try it!

#5935 **$39.95**(3.50)

Deluxe Eyepiece Case

Holds up to 10 eyepieces plus barlow. Die-cut foam insert. 8 1/2"x12 1/2"x3 1/8".

#5913 **$17.95** (1.95)

56 Page 1987 Catalog
Huge selection of telescopes and accessories plus informative articles on astronomy, astrophotography, and more!
Call or Write today!

CALL TOLL-FREE
800-447-1001
In California:
800-443-1001

To Order: Just call our Toll-Free Number with your Visa or MasterCard, or send your order with personal check or money order. California residents add 6% sales tax.

Shipping charges to anywhere in the 'lower 48' States via UPS Ground or U.S. Mail are listed in (parenthesis) after each price. Additional charges apply to other areas or Air Shipment orders.

Sky-Gazers Exchange

Only noncommercial advertising is acceptable, except offers of professional observatory equipment and one-of-a-kind items, want ads, and job opportunities at publisher's discretion. Remittance must accompany order: maximum length 100 words; 75 cents a word, including address; minimum $15.00 per ad. Closing date is 10th of second month before publication. Ad must contain individual advertiser's name and street address (post office box numbers alone not acceptable); telephone number is desirable; ads subject to editing. We cannot acknowledge classified ad orders nor send checking copies to prove insertion. Sky Publishing Corp. assumes no responsibility for statements made in classified ads, nor for the quality of items advertised for sale. Orders accepted only for one ad per issue at a time. Write Ad Dept., Sky & Telescope, 49 Bay State Rd., P. O. Box 9102, Cambridge, Mass. 02238-9102.

TRADE or sell Meade 2080 loaded for astrophotography and Unitron 4″ equatorial refractor. Will trade for Celestron 14 or Celestron 11, or sell for $1,750 each. Roger Black, 2409 Trail Tree Ct., Burleson, Tex. 76028. Phone: 817-295-4696.

QUESTAR: Serial No. 8-DR-7281-BB. Davis & Sanford heavy-duty tripod, 16- and 24-mm eyepieces, and leather case for telescope and accessories, $2,500. R. E. Moore, 129 N. Pineapple Ave., Sarasota, Fla. 34246. Phone: 813-955-4572.

UNITRON 3 1/7″ refractor with clock drive, Unihex, 1¼″ eyepieces, camera adapter, and equatorial mount. Gary Phillips, 2197 Tabor Lake Circle, Lexington, Ky. 40502. Phone: 606-266-6630.

BYERS 58 German equatorial mount and pedestal with electric R.A. and declination drives, Byers dual-axis drive corrector, and more, $1,580 or best offer. Wanted: Astro Physics 706 mount. Eric Bunn, 178 Main St., Westford, Mass. 01886. Phone: 617-692-9592.

FOR SALE: *Sky & Telescope,* December, 1969, through January, 1987, $180 or best offer. Brad Schaefer, 1511 Pinelake, Bowie, Md. 20716. Phone: 303-249-6888.

DAYSTAR H-alpha filter for Celestron 8, $1,600. Paul D'Errico, 10293 E. Peakview, #204, Englewood, Colo. 80111. Phone: 303-771-1404.

QUESTAR 7, excellent condition, 1 year old, $6,000. James Tubbs, 1059 Alameda, #104, Belmont, Calif. 94002. Phone: 415-341-2852.

CELESTRON 8″ Schmidt camera, 2 filmholders, perfect condition, $1,200. Porter Kier, Lottsburg, Va. 22511. Phone: 804-529-6071.

PHOENIX area subscribers to *Sky & Telescope* should apply to the Phoenix Astronomical Society for membership. Raul Espinosa, 6945 E. Gary Rd., Scottsdale, Ariz. 85254. Phone: 602-948-3617.

CELESTRON 14 fork mount, complete, with wedge, tripod and heavy-duty drive corrector. New, August, 1986. $2,200 plus shipping; all reasonable offers considered. Greg Terrance, 3127 Plank Rd., Lima, N. Y. 14485. Phone: 716-624-1357.

QUESTAR 3½″ duplex with Cer-Vit mirror, coatings, 6 accessories, Linhof heavy-duty tripod, modified Nikon F with 2 lenses, $2,400 or best offer. Jim Shipp, 1210 Cacique St., #27, Santa Barbara, Calif. 93103. Phone: 805-962-7189.

WANTED: 4″ Unitron altazimuth mount with counterweight. Will consider purchase of entire telescope. Bill Griffin, 3725 Beacon Lane, Virginia Beach, Va. 23452. Phone: 804-340-4189.

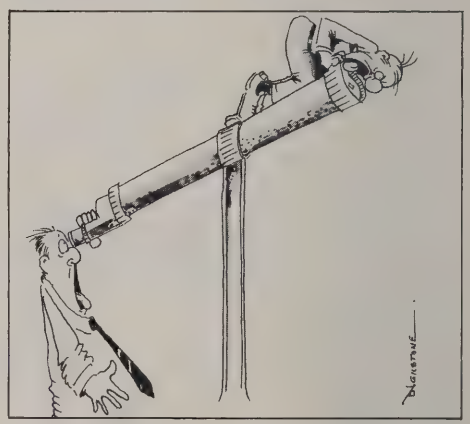
MEADE 2080-LX3 with MCSO, wedge, tripod, declination motor drive, quartz hand control, carrying case, and eyepieces. Mint condition. Best offer. Robert Faulkner, 15733 Rancho Ramon Dr., Tracy, Calif. 95376. Phone: 209-836-3004.

WANTED: *Atlas Eclipticalis* in good condition. Alan McGowen, 1580 San Tomas Aquino Rd., #4, San Jose, Calif. 95130. Phone: 408-378-8607.

QUESTAR 7 barrel and 5 Questar Brandon eyepieces. Best offer. Mark Harris, 712C Bruton Bends, Richardson, Tex. 75081. Phone: 214-783-8322.

TUBE ASSEMBLY, 6″ f/10 refractor, $650. 12½″ reflector tube assembly with rotating rings, fiberglass tube, less optics, $450. Equatorial mount with 1″ shafts and drive, $100. Steve Kalasky, 2948 Newton Falls Rd., Newton Falls, Ohio 44444. Phone: 216-538-2857.

TELE VUE wide-field eyepieces, 15- and 24-mm, $75 and $90, respectively. Lumicon Cassegrain Easy-Guider (for Olympus cameras), $150. Andy Johnson, 237A Brazilian, Palm Beach, Fla. 33480. Phone: 305-655-9389.



Astronomical Jigsaw Puzzle

★

The Illustrated Milky Way Sagittarius and Scorpius

★

$12.00

plus $2.00 shipping and handling.
Texas residents add 7 1/8% sales tax.

This 1,000-piece 20 by 27-inch puzzle is a color photograph of the Milky Way. Coordinate lines, constellations, planets, and dozens of stars and deep sky objects are located and identified in color.

Deen Publications

P.O. Box 831991 Richardson, TX 75083

(214) 231-0338

VISA

Allow 4 to 8 weeks for delivery.

SPACE*SHIRTS

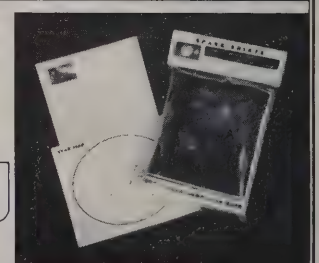
The Science Gift You Can Wear

FULL COLOR - PHOTOGRAPHIC IMAGES OF DEEP SPACE

INCLUDED IN EACH T-SHIRT PACKAGE:
* Location Star Map * Astronomical Description

ORDER EARLY FOR CHRISTMAS DELIVERY

FIRST QUALITY CUSTOM DESIGN T-SHIRTS



*A101 - ANDROMEDA GALAXY
*A102 - HORSEHEAD NEBULA
*A103 - LOS ANGELES, EARTH
*A104 - THE ORION NEBULA
*A105 - DEEP SPACE COLLAGE

◆ ALL IMAGES ◆ also available on SWEAT SHIRTS
A new FULL COLOR technology. Soft light feel to image. Will not wash out or fade
◆ All shirts white ◆

ONE T-SHIRT PACK...$12.95
ONE SWEAT SHIRT....$21.95
$1.00 off each for 2 or more

SPECIFY: S M L XL
or youth size: Large only

Postage & Handling $1.50 for 1-2 T-shirts. Each addl. 50¢
Sweats $1.50 for one. 50¢ addl
Canada add $1.00 per shirt.
(other foreign inquire)
Mastercard & Visa

WRITE FOR FREE BROCHURE

SCIENCE & ART PRODUCTS P.O. BOX 1166
MALIBU, CA 90265 • (213) 456-2496

SATISFACTION GUARANTEED

Amateur Astronomers

Conducted by Stephen James O'Meara

VARIABLE STAR DAY AT LEIDEN

CENTURIES-OLD Leiden Observatory in the Netherlands — where such world-renowned astronomers as Ejnar Hertzsprung, Willem de Sitter, and Jan Oort conducted research — was the scene for an international gathering of variable star observers last June. Thomas Williams, president of the American Association of Variable Star Observers (AAVSO), Jan Hers, director of the Variable Star Section of the Astronomical Society of Southern Africa, and I joined 35 observers from the Netherlands and Belgium in a "Variable Star Day" celebration. The Variable Star Section (WVS) of the Netherlands Association of Astronomy and Meteorology arranged our trip so we could meet its members after our stay in Paris (see page 480).

On my way to Leiden I stopped in Goutum, a small, quaint town in the northern Netherlands, to visit Hendrik Feijth, recorder for WVS, who has logged over 50,000 variable star estimates from his modest observatory in the heart of this well-lit town. He uses an 8-inch Newtonian and a 12-inch Dobsonian to make his observations. On chilly nights he slips into a large pair of wooden shoes with booties, which the WVS presented to him in recognition of his 50,000th observation.

Built in 1633, Leiden Observatory was the center of much professional research until 1980, when the Dutch government ceased to fund it. Now amateur astronomers run the facility and its instruments. Photograph by Thomas Williams.

The next day at Leiden I heard Feijth and Georg Comello recount the history of the WVS. Lukas Plaut of Kapteyn Astronomical Observatory founded the group in 1960. Today it has about 15 active members who make some 8,000 observations a year. To date the WVS has accumulated about 150,000 estimates. Since 1980 they have sent observations directly to the AAVSO.

WVS members have to be extremely selective about what stars they observe, because bad weather, light pollution, and the high latitude of the Netherlands impose severe limitations. Observers have little choice but to concentrate on long-period and semiregular variables, since these stars need watching only once every 10 days. However, some members do keep vigil on eruptive variables.

The WVS has just started to computerize its historical data. It also uses a computer to schedule observations, determine times of variable star maxima and minima, process the incoming observations, and prepare data for the *Reports* of the WVS and the data files of the AAVSO.

In neighboring Belgium, the variable star observers also work hand in hand with the AAVSO. The Belgian Vereniging voor Sterrenkunde (Association for Astronomy) started several working groups, including one for variable stars in 1969. Since its founding, this group of about 10 amateurs has compiled more than 50,000 observations.

The program stars of the Belgian observers have also been carefully chosen to maximize observing efficiency in the face of bad weather and very severe light pollution. The group also specializes in photoelectric observations, as well as the photographic study of suspected variables.

Both Belgian and Dutch amateurs make use of dark-sky sites outside their countries. For example, I learned that Flemish amateur Dany Cardoen has a year-round observing facility in Provence, France. For a reasonable fee Cardoen provides up to 25 amateurs with full accommodations, observing platforms, and electricity — they must bring their own telescopes. This site, like those at Pic du Midi in the

THE "HIGH-LITE"™ BINOCULAR SYSTEM:

COUPLED WITH THE "HIGH-LITE"™ SUPPORT, OUR FINE BINOCULARS FEATURE HIGH TRANSMISSION PRISMS & OPTICS FOR THE BRIGHTEST IMAGE ON THE MARKET AND OUR DESIGN DETAIL MAINTAINS SUPERIOR COLLIMATION. OUR 11×80 IS CLEARLY THE FINEST OF ITS CLASS.

FOR ILLUSTRATED BROCHURE, CALL OR WRITE: CELESTIAL INNOVATIONS, HCR BOX 3228, DEPT. S, ORACLE, AZ 85623 (602) 896-9109 (Patented)

GALAXY OPTICS

MANUFACTURERS OF FINE QUALITY NEWTONIAN TELESCOPE OPTICS INTRODUCES

ULTIMATE IMAGE™ 2.00" thickness lightweight mirrors in 16.0", 18.0", 20.0", and 22.0" diameters.

All ***GALAXY OPTICS*** mirrors are totally hand-figured and tested through various stages of completion to assure a professional quality 1/20th wave paraboloidal surface.

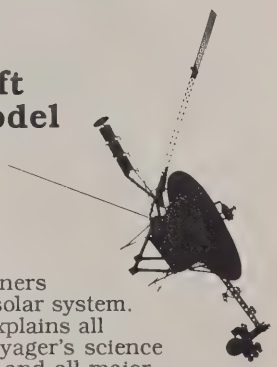
GALAXY'S full thickness (1:6) and lightweight mirrors (2.00") are made from fine annealed *molded* Pyrex mirror blanks and are available with a choice of three outstanding reflective coatings.

For a complete product catalog mail $1.00 to:

GALAXY OPTICS

1880 SOUTH FLATIRON COURT, SUITE A-1, BOULDER, COLORADO 80302 (303) 665-8902

Voyager Spacecraft Paper Model



A highly detailed 3-D model of the historic mariners to the outer solar system. Shows and explains all eleven of Voyager's science experiments, and all major spacecraft components. Comes with an illustrated, educational spacecraft description, highlights of Voyager's mission, and assembly instruction booklet. Made of precision laser-cut card stock (black, yellow, white, and gold foil). Diameter of central dish antenna 11cm; 40cm overall. Assemble from 26 pre-cut parts by folding, inserting tabs, applying white glue (not supplied). A photographic silhouette of assembled model is shown above.

ORDER ST-11 MODEL KIT. . . . $9.95 Postpaid.

California residents add $.65 tax. Foreign payments must be U.S. funds drawn on a North American bank, or International Money Order. No extra charge for foreign mailing.

Neptune Pacific

953 E. Colorado Blvd. Suite 201

Pasadena, California 91106

Dealer & school inquiries welcome.

French Pyrenees and Jungfraujoch in Switzerland, are in high demand by European amateurs, particularly by those who live where clear and dark skies are a rarity.

Today, even Leiden Observatory sits in the middle of a booming metropolis. Originally it was built on the roof of the old Academy Building on the outskirts of town in 1633. It was moved to its present location in the mid-1800's. Professional astronomers ran the observatory until the Dutch government recently discontinued its funding. Amateur astronomers now have unrestricted access to the telescopes, providing they continually overhaul and service them. The Working Group of Leiden Observatory, chaired by Peter Serne, has now put all but one telescope into full operation.

The observatory's 17.7-inch reflector is the second largest in the Netherlands. Despite the country's intense light pollution, the telescope reaches magnitude 14.4 visually, so observers can follow the activity of some faint, eruptive stars and of long-period variables. Leiden's 10½-inch Clark refractor is used for double stars and the planets, as well as for photoelectric work.

The amateurs have also focused on educating the public on astronomy. And they do this with little financial support from the Dutch government. The amateurs' efforts at Leiden truly touched me — I'd like to see a similar arrangement in the United States at observatories with unused instruments.

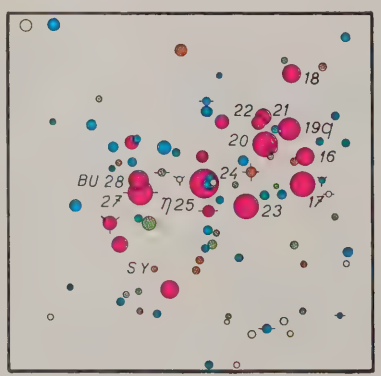
I was also impressed with the determination of these observers in a country plagued by overcast skies and adverse artificial lighting. I respect them for taking to task the difficult job of maintaining a professional observatory and its equipment, and for using the facility to contribute valuable astronomical data.

JANET AKYUZ MATTEI
AAVSO
25 Birch St.
Cambridge, Mass. 02138

UNAVAILABLE
UNTIL NOW!
ENHANCE YOUR VIEWING PLEASURE
BY ELIMINATING DISTRACTING LIGHTS
WITH
BINOCULAR EYESHIELDS
• HIGH QUALITY DESIGN
• FOLD OVER CAPABILITY
• ONE SIZE FITS ALL
(ORDER TODAY - LIMITED SUPPLY)
SEND $8.95 or $14.00 for 2 pair & $.75 shipping to...
GMM RUBBER CO.
153-A LAKEVIEW CT., PEWAUKEE, WI 53072

ATLASES BOREALIS AND AUSTRALIS ON SALE!

Get both for the price of one! You've always wanted these beautiful atlases — now's your chance. They were produced by Antonin Becvar at the Czechoslovak Academy of Sciences. All stars to about magnitude 9.0 are plotted, with many fainter ones also included. The *Borealis* covers the sky north of declination +30° and has 92,000 stars. The *Australis* plots 104,000 stars south of declination −30°. (*Atlas Eclipticalis* is no longer available.) Virtually all stars are color-coded by spectral type: purple for *O* and *B*, blue for *A*, green for *F*, yellow for *G*, orange for *K*, and red for *M*, *R*, *N*, and *S*.



Each chart indicates *all* double and multiple stars down to combined magnitude 10.0, along with many fainter ones. Many double stars are marked by two colors indicating the spectral type of each component. All variable stars that become as bright as magnitude 10.0 are plotted, with an indication of the range in brightness of each. Deep-sky objects are not shown. Each volume has 24 huge charts, 13½ by 19 inches, wire-bound in sturdy, flexible Lexotone covers. The uniformly large scale of two centimeters per degree allows a star's 1950 coordinates to be read with considerable accuracy using a plastic overlay.

These are important additions to any stellar astronomer's library. Get them while you still can! This special price applies only to the pair. *Atlases Borealis* and *Australis*, **$49.95** for the pair. *Offer good while supply lasts; price includes postage. Both atlases must be shipped to same address.*

S0019 *ATLAS SALE* . . . **$49.95**

Mass. residents add 5% sales tax. Foreign add 15% for postage. Payments must be in U. S. funds drawn on a U. S. bank, or by International Money Order. **Use the order form in the center of this issue, or write to:**

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, Mass. 02238-9102

Amateurs, Professionals Unite in England

WHAT are the most useful observations that amateur astronomers can make to aid professionals? And in what ways can professional astronomers assist the amateur? These were the questions tackled at a historic joint meeting of the British Astronomical Association (BAA) and the Royal Astronomical Society (RAS). The meeting, held on March 14th, filled the Scientific Societies' Lecture Theatre in London's Savile Row. Organizers George Wilkins of the Royal Greenwich Observatory (RGO), and Heather Couper, vice president of the BAA, underscored that this was the first national meeting of amateur and professional astronomers in the United Kingdom.

BAA members have been making significant astronomical observations for nearly 100 years. Here are brief summaries of this work, as adapted from the official meeting report. The full report will appear in the BAA *Journal*.

Comets. Graham Keitch noted that, thanks to Comet Halley, amateur astronomers have had more involvement with professionals in comet research over the past few years than ever before. The work of the BAA's comet section involves: (1) drawings of the tail, inner coma, and jets; (2) magnitude estimates; (3) photography of the head and tail; (4) astrometry; (5) discovery; (6) photoelectric photometry; (7) orbit computations.

Aside from publishing its results in the BAA *Journal*, the comet section has links with professional astronomers in England through the *International Comet Quarterly* and the IAU's Central Bureau for Astronomical Telegrams. Soon the BAA will have a computer link with the bureau. In the special case of Comet Halley, the BAA helped coordinate observers in the United Kingdom and had strong ties to the International Halley Watch. Iwan Williams of Queen Mary College confirmed that professional astronomers in England appreciated this valuable work of amateurs and expressed hope that the collaboration continues.

Meteors. Bertil Lindblad of Lund Observatory in Sweden chairs IAU Commission 22 on meteors. He explained that since most radar facilities for meteor studies are closed, a major shower would probably be recorded now only by amateurs. Several serious groups of amateurs in the United Kingdom, the Netherlands, Belgium, and Australia monitor meteors. Their work includes visual observations, forward-scatter radar detections, and orbit calculations with personal computers.

For example, amateurs have monitored the Sigma Puppid meteor shower in 1967,

1972, 1977, and 1982. Very few of these meteors, which may be related to Comet Giacobini-Zinner, have been seen — except in 1982, when observers in Western Australia reported a zenithal hourly rate of about 75 meteors that persisted for two to three hours. Lindblad pointed out that this number may seem low because these meteors were catching up with the Earth from behind. If scaled to the Perseids, the rate would climb to 2,000 to 3,000!

Continued observations could bear on the decision of the European Space Agency to retarget the Giotto spacecraft. Giacobini-Zinner is the only comet that Giotto can travel to, so the more knowledge we have on the meteor stream the better. Lindblad believes that this is an excellent incentive to observe the Sigma Puppids.

Asteroids. Andrew Hollis, director of the BAA asteroids and remote planets section, noted that despite some 3,600 numbered asteroids, only a few "asteroiders" remain active. Yet many amateurs have telescopes of 12- to 16-inch aperture, cameras, or photoelectric photometers that could be turned to these minor bodies. And they do not have the observing constraints that plague professionals. However, poor weather and lighting conditions in the U. K. impose magnitude limits on observers — about 12 to 13 for **V** band photoelectric photometry and 15 to 16 for visual photometry and photography. Nevertheless, each year several hundred asteroids reach magnitude 13 or brighter.

The BAA asteroid program concentrates on individual bodies, rather than a statistical survey of many, and works at generating light curves from which rotation periods can be determined. Hollis remarked that cooperation between amateurs and professionals in this field is essential. Recently, Alan Harris of NASA's Jet Propulsion Laboratory assisted the BAA in a study of 8 Flora, which provided a new solution to that asteroid's rotation, as well as data indicating that its polar axis is more inclined than previously thought. Richard Miles in the U. K. and Kenneth Zeigler in the U. S. (August issue, page 192) independently determined that the rotation period of 116 Sirona was 12 hours, instead of the published value of about 13.6 hours.

Occultations. Extensive interaction occurs between professionals and amateurs in this area. In fact, Gordon Taylor, director of the BAA computing section, deplores the distinction between the two. When he worked for the RGO, two-thirds of the results from lunar occultations had come from amateurs. The same involvement applies to occultations by planets, minor planets, and satellites. For example, the July 7, 1959, occultation of Regulus by Venus yielded a diameter for the planet with a formal error of only 8 kilometers and indicated no measurable oblateness. This analysis was based on 160 observations, all but one being visual.

The first accurate determination of Neptune's diameter came from an occultation on April 7, 1968. Photoelectric observations from Japan, Australia, and New Zealand showed that Neptune was not 45,000 km in diameter, as previously believed, but somewhat more than 50,000 km. Taylor added that even if the photoelectric sites had been clouded out, the

Amateurs To Get RGO Telescopes?

Since the Science and Engineering Research Council (SERC) decided to move the Royal Greenwich Observatory (RGO) from Herstmonceux to Cambridge, England (February issue, page 150), the future of its telescopes has remained in doubt. The "equatorial group" consists of six domes: one contains a video theater; two have instruments (a 26-inch and a 13-inch) used by the RGO for astrometry; one has a 36-inch for testing instruments for the La Palma telescopes; another has a 30-inch used by British universities for testing equipment; and one houses a Hewitt camera for satellite tracking.

Some have suggested that the telescopes be made available to the amateur astronomical community of the United Kingdom. Such a venture, however, would involve tens of thousands of dollars per year. RGO had looked at the prospect of approaching businesses for the funds, but by law commercial firms cannot donate money to a government institution. But George Wilkins of the RGO feels the revenue generated from public admissions would be sufficient for operations. Various amateur groups would need to organize themselves and find money to maintain the telescopes and domes. The RGO has recently suggested it might set up a trust fund for professional-amateur collaboration in this effort. It would provide money for the groups to organize residential courses or produce low-cost instruments.

Perhaps something will soon come along that involves both professionals and amateurs, and appeals to the public. But everything depends on the future of the site. It might be necessary to mothball the telescopes until adequate funding is secured.

LADIES ONLY!

Just a note to the ladies from "Mrs." Jim's Mobile Ind. Every year I tell my husband, "I never know what to get you for Christmas. You have everything." Last year he called my bluff with a list of Naglers he didn't yet own. He only had a Nagler 13. Poor dear! He's looking through Naglers and I'm looking through starry eyes at our old dinnerware.

I am wondering, ladies, has your husband been preparing you for the inevitable, telling you how he really needs this new scope with all the widgets on it if he is ever going to be a success as an amateur astronomer? Well, maybe his old scope just needs a little new life in it. It's probably basically a good scope, and many astronomers think some of the old scopes still have the best optics. In time for Christmas, my husband has just developed a MOTOTRAK drive corrector with all the widgets on it. It will make his old scope look, feel, and act like one of those new-fangled ones. And look at all the money you might save if he doesn't need to buy a new scope.

I suggest you may want to leave this ad lying open around the house to get his response. In the meantime, I know what I'm putting under the tree this year.

Merry Christmas and thanks for your time.
DeEtta

MOTOTRAK is a deluxe drive corrector. (Only the hand unit is shown above.) It is state-of-the-art CMOS, digital quartz-driven, not just quartz-reference. There is a big difference. For instance, tracking is not approximately set by an invisible pointer on a knob in the dark, but is locked in so accurately by the quartz-driven circuitry, and indicated by a light-emitting diode, that there will never be any doubt at what rate you are tracking.

- Power-pack battery will operate C8 approximately 9 hours
- Dec. output with reversing switch
- Jacks for setting circles and map lights
- Accuracy 0.005%

MOTOTRAK . . . . . .$299.95 ppd.

CHRISTMAS INTRODUCTORY SPECIAL!

FREE — MOTOFOCUS or your choice of "snap-on" MOTODEC (except GEM and Polaris) with the purchase of MOTOTRAK until Dec. 24. MOTOTRAK is designed to operate all Motofocus units, so the free Motofocus will not include the regular hand unit.

VISA, MC, check OK. We pay postage. Foreign: send bank check in U. S. $.

JIM'S MOBILE IND.
1960 Co. Rd. 23
Evergreen, CO 80439
(303) 277-0304

ODYSSEY
TELESCOPES
Seeing the *real* Universe

FREE INFORMATION
- ODYSSEY GUIDE
- OWNER COMMENTS
- REPRINTS
- DOBSONIAN INFO.
- COULTER OPTICAL NEWS
- PRODUCT LIST

ASK FOR IT!

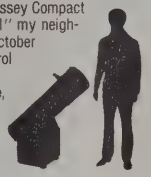
8 inch $239.50

"On the Moon and Jupiter, the Odyssey 8 showed as much detail as several 8" Schmidt-Cassegrains nearby."
David McGough, Millington, N.J.

"It is worth twice what I paid, but please don't raise the price. I want to get my son one in a few years."
Tom Johnston, Boulder, Colo.

10.1 inch $299.50

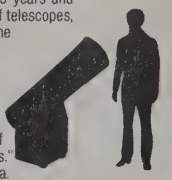
"Careful star-testing of the 10.1" Odyssey Compact I received last March and of the 10.1" my neighbor Doug Barnes picked up in mid-October suggests a high level of quality control which is astonishing. Diffraction patterns are virtually interchangeable, and both scopes show textbook optical results (both in-focus and out-of-focus)."
Lee Johnson, Coquitlam, B.C. Canada



13.1 inch $499.50

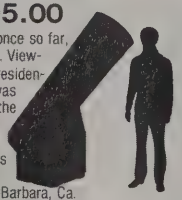
"In amateur astronomy for over 35 years and I have seen my share of all kinds of telescopes, good and bad. To say the least, the Odyssey 1 outperforms anything that I have seen!!"
Richard Ziegler, Maumee, Ohio

"There is not another telescope of equal size in our club that can touch the clear image and ease of operation that Odyssey 1 provides."
Mark Davenport, Pinellas Park, Fla.



17.5 inch $995.00

"I've only had a chance to view once so far, but am thoroughly thrilled with it. Viewing from a (Santa Barbara, Ca.) residential front yard, the Orion Nebula was indeed a treat – reddish tinges on the predominating green, with many subtle wisps and lanes very clear. The Andromeda Galaxy was surprisingly bright, as was its companion." David Broad, Santa Barbara, Ca.



Lightweight Mirror Optics at Low, Low Prices:
Pyrex, 1/8 wave, aluminized & overcoated

10 inch f/5.6	$129.50
10.1 inch f/4.5	$134.50
12.5 inch f/6	$249.50
13.1 inch f/4.5	$254.50
17.5 inch f/4.5	$590.00

Elliptical Diagonals

1.83" — $15.50	3.10" — $ 34.50
2.14" — $18.95	4.25" — $ 69.50
2.60" — $22.50	6.25" — $150.00

EASY TO ORDER ... Phone or mail your order in today. Visa/MasterCard accepted. All telescopes are shipped freight charges collect. All mirrors are shipped prepaid in the contiguous U.S.A. No sales tax on out-of-state orders. Phone orders Mon-Fri 8 am-4:30 pm local time.
Call 1-714- 659-4621

- **30 days returnable**
- **30 days exchangeable**
- **2 years materials and workmanship**

Coulter Optical, Inc.
P.O. Box K
Idyllwild, CA 92349-1107
"OPTIMUM OPTICS AT MINIMUM COST SINCE 1967"

visual data would have led to the same conclusion.

Artificial satellites. Desmond King-Hele of the Royal Aircraft Establishment pointed out that the advent of artificial satellites in 1957 provided an attractive novelty for observers for whom meteors were too fast and planets were too slow. Visual work was more accurate and useful than anyone had expected. Observers amassed some 20,000 recorded sightings per year for 20 years. (King-Hele also does not distinguish between amateur and professional astronomers; he refers to amateurs as "volunteer observers.")

Although satellite observations are astronomical in nature, they are most useful to geophysicists. In particular, they give important data on the density of air from altitudes of 100 km to 1,000 km, the rotation of the atmosphere, and the shape of the Earth. King-Hele stressed the importance of visual observations and lauded the work of Russell Eberst and David Hopkins, each of whom has contributed more than 100,000 observations. More are needed.

Variable stars. The BAA has a tremendous archive of variable star estimates of all types that date back to around 1900. Today, however, emphasis is primarily on eruptive variables, such as novae and supernovae. Melvyn Taylor of the BAA's variable star section stressed that analyzing and publishing results about these stars are as important as watching them. Amateur astronomers certainly make enough important observations that professionals should want to copublish papers with them. Peter Andrews of the RGO recalled a recent example: in the *Monthly Notices* of the RAS, New Zealand amateur Frank Bateson coauthored a paper on VW Hydri that included data from the IUE, Exosat, and Voyager 2 spacecraft.

Andrews thought that amateurs and professionals should seek objects of common interest. Professionals have access to satellites such as IUE, whose programs could be interrupted to observe such "targets of opportunity." Amateur observations could be coordinated with those of professionals and the results communicated rapidly between the parties and to the astronomical community at large.

FUTURE COLLABORATION

Wilkins reminisced that while working at the Nautical Almanac Office, he was critically dependent on many observations from amateurs worldwide. Today, he added, amateurs not only further research but also create greater public understanding of, and support for, astronomy. This is especially important now that government funding is being "squeezed."

One framework for future amateur-professional collaboration, Wilkins suggested, would work as follows: Professional astronomers would specify objects to be observed and would provide predictions; the amateurs would collect and process the data; then the professionals could undertake a "massive analysis," leading to joint publication with the amateur astronomers involved.

After further discussion the general feeling was for more amateur-professional meetings. In the United Kingdom subsequent events would be restricted to specific areas of research to allow in-depth searches for areas of mutual interest. The council of the BAA is considering having a major conference to mark its centenary in 1990. This meeting will explore further the interactions between professional and amateur astronomers and will concentrate on the modern observing techniques and interpretations.

NIGEL HENBEST
British Astronomical Association
Burlington House, Piccadilly
London W1V 9AG, England

THE BAA SECTIONS AND THEIR DIRECTORS

Sun. Leonard M. Dougherty, Dog Hill Farm, Barkisland, Halifax, West Yorkshire HX4 0ES.

Moon. Geoff W. Amery, 183 Church Rd., Earley, Reading RG6 1HN.

Terrestrial planets. Richard M. Baum, 25 Whitchurch Rd., Great Boughton, Chester CH3 5QA.

Asteroids and remote planets. Andrew J. Hollis, 85 Forest Rd., Cuddington, Northwich, Cheshire CW8 2ED.

Jupiter. William E. Fox, 40 Windsor Rd., Newark, Nottinghamshire NG24 4HX.

Saturn. Alan W. Heath, 136 Trowell Grove, Long Eaton, Nottinghamshire NG10 4BB.

Comet. Michael J. Hendrie, Overbury, 33 Lexden Rd., West Bergholt, Colchester, Essex CO6 3BX.

Meteor. George H. Spalding, 2 Hyde Rd., Denchworth, Wantage, Oxfordshire OX12 0DR.

Aurora. Ron J. Livesey, Flat 1, 2 East Parkside, Edinburgh EH16 5XJ.

Variable star. Doug R. B. Saw, Upanova, 18 Dollicott, Haddenham, Aylesbury, Buckinghamshire HP17 8JG.

Deep sky. Denis G. Buczynski, Fell Acre, Conder Brow, Littlefell Lane, Scotforth, Lancaster LA2 0RQ.

Computing. Gordon E. Taylor, Five Firs, Cinderford Lane, Cowbeech, Hailsham, East Sussex BN27 4HL.

Historical. H. Derek Howse, 12 Barnfield Rd., Riverhead, Sevenoaks, Kent TN13 2AY.

Artificial satellites. Howard G. Miles, Lane Park, Pityme, Saint Minver, Wadebridge, Cornwall PL27 6PN.

Reporting of fireballs and other transient or unusual phenomena. Howard G. Miles (address above).

SOLAR SKREEN • ASTRO TULE • NO DU CAPS • SUPER FINDER • ULTIMATE FINDER • STEREO⊙CULAR

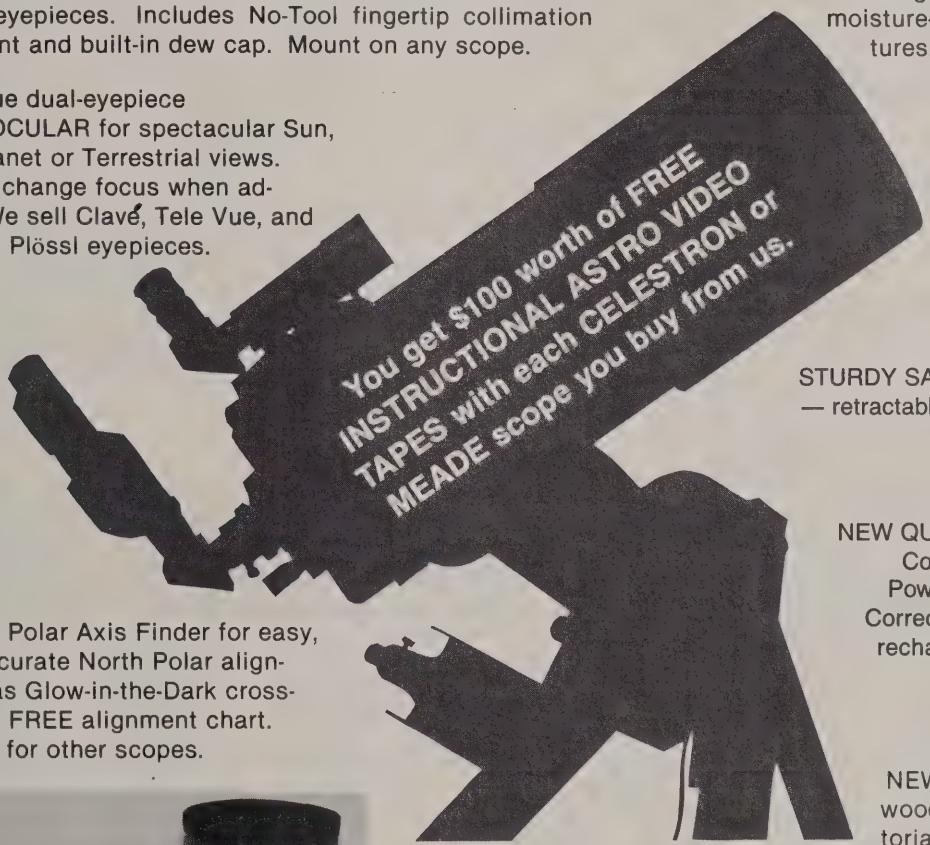
MICRO DRIVE • MINI MOUNT • SOLAR PROMINENCE PROBE • ISOSTATIC MOUNT • CELESTIAL NAVIGATOR

Your astronomical friend — Roger W. Tuthill — is now available to help you with your hobby in a personal way. He has compressed his 28 years of experience in amateur astronomy into two VCR VIDEO TAPES. One tape gives information on Basic SCT operation (50 minutes long), the other one Astrophotography with SCT scopes (30 minutes long). Tapes may be rented for as little as $19 each. Inquire about free rental for schools or clubs.

Giant Finders, 50mm & 80mm diam., right-angle and straight-through easy-to-see Glow-in-the-Dark crosshairs with 1¼″ focusable eyepieces. Includes No-Tool fingertip collimation adjustment and built-in dew cap. Mount on any scope.

The unique dual-eyepiece STEREO⊙CULAR for spectacular Sun, Moon, Planet or Terrestrial views. Does not change focus when adjusted. We sell Clavé, Tele Vue, and Celestron Plössl eyepieces.

No-Du-Caps — lightweight, heated with moisture-absorbing features. Easily attach without tools.
SOLAR SKREEN SUN FILTERS for all scopes.



STURDY SAFETY HANDLE — retractable — convenient

NEW QUARTZ-LOCKED Cordless Star Trap Power Module Drive Corrector with built-in, rechargeable, sealed batteries.

Precision Polar Axis Finder for easy, quick, accurate North Polar alignment. Has Glow-in-the-Dark crosshairs and FREE alignment chart. Available for other scopes.

NEW Knot-Free Redwood Isostatic Equatorial Mount. A combination wedge and tripod with built-in latitude adjustment. Includes 3 No-Tool knobs and vibration-resistant pads. Lightweight, folds up for easy portability and storage. For any size Schmidt-Cass. Scope.

Every large size Celestron, Meade or Bushnell Schmidt-Cassegrain scope needs our thirsty, light-weight, heated NO-DU CAPS to gently, continuously absorb moisture.

CALL TOLL-FREE 1-800-223-1063
And Talk to Astronomers, NOT Clerks.
In New Jersey call 201-232-1786
We stock all accessories for all scopes.

Send a large (9″x12″ — 3 oz) Manila Self-Addressed Stamped Envelope for our complete information Kit including "Tuthill's Twenty-Two Telescope Tips" and the "Special Tuthill Maintenance Instructions for Celestron Scopes."

We export scopes with any voltage and frequency to either hemisphere.
Time Payment Plan Available.

WE REPAIR SCOPES
MasterCard, VISA *Trademark
Telephone: (201) 232-1786

ROGER W. TUTHILL, INC.
11 Tanglewood Lane, Dept. S, Mountainside, N.J. 07092

NEW ENGLAND ASTRO-OPTICS, INC.

• QUESTAR • MEADE • TELEVUE •
BUSHNELL/BAUSCH & LOMB • JSO
• CELESTRON •

EXPORT AVAILABLE

CATALOG PACKAGE $3.00
Box 834, Simsbury, CT 06070
203-658-0701
• OUR 5th YEAR •

ZERODUR MIRRORS

Exp. coeff. 0 to 1 × 10^{-7}/°C.
Ideal for solar, lunar, planetary use. 30× the thermal figure stability of Pyrex. 6:1, 4" to 20", any f/no.

4"f/5	3 micron finish ready to polish	$90
10"f/5	3 micron	$660

Request brochure on our wide-field 40mm f.l. to 2mm f.l. eyepieces and 4" f/6 6° flat sky-field apochromat.

AUGEN OPTICS
947 Parkside Lane, Lancaster, PA 17601
(717) 295-4679

INDONESIA SOLAR ECLIPSE MARCH 17-18, 1988

Expedition Leader: Mr. Bill Peters, Manitoba Planetarium, Winnipeg

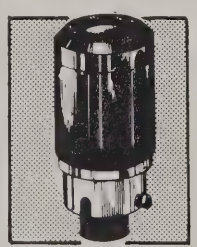
Departing March 13, 1988, visiting Sumatra, Orangutan Rehabilitation Centre, and Bali. Extensions to Singapore, Hong Kong, Australia, and New Zealand.
Lectures on astronomy, Indonesian wildlife, history, and local culture.
A land-based observation site is better for setting up your telescope.
For information, write to:

east african travel consultants inc.
574 Parliament Street
Toronto, Ontario
M4X 1P8
Canada
(416) 967-0067

Edelman's

Call Fred First, Call Fred Last!
WE WILL BEAT ANY ADVERTISED PRICE!

TeleVue SERIES II EYEPIECES
WE HAVE THEM ALL AT SUPER LOW PRICES.



"NEW" ORACLE 3" REFRACTOR TELESCOPE **$679.95**

PLOSSL S	**SPECIAL**
55mm Plossl	$154.95
40mm, 32mm Plossl	$87.95
26mm, 21mm, 17mm, 13mm	$75.95
10.5mm, 7.4mm Plossl	$75.95
WIDEFIELD	**SPECIAL**
40mm Widefield	$239.95
32mm Widefield	$189.95
24mm Widefield	$134.95
19mm Widefield	$119.95
15mm Widefield	$109.95
NAGLERS	**SPECIAL**
13mm Nagler	$209.95
11mm Nagler	$199.95
9mm Nagler	$189.95
7mm Nagler	$154.95
4.8mm Nagler	$129.95
"NEW" NAGLERS 82°	**SPECIAL**
20mm Nagler	$299.95
16mm Nagler	$249.95
12mm Nagler	$219.95

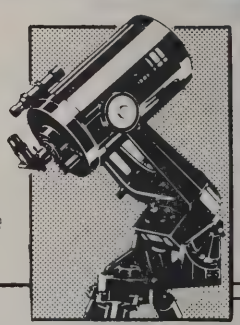
8" UNITS
2080LX5-MCSO ... $1,699.95
2080LX3-MCSO ... $1,399.95
2080 GEM HTC $799.95

10" UNITS
2120LX5-MCOG ... $2,649.95
2120LX3-MCSO ... $2,289.95
2120 GEM-MCSO .. $1,699.95

4" UNITS
2045LX3 ..... $789.95
2045 ..... $579.95

Meade

2045&2045LX3 include table top tripod



"NEW" MEADE MTS TELESCOPES

MTS SN-6 *Schmidt-Newtonian 6" (F-5)* $549.95
MTS SN-8 *Schmidt-Newtonian 8" (F-4)* $799.95
MTS SC-8 *Schmidt-Cassegrain 8" (F-10)* $799.95
MTS SC-10 *Schmidt-Cassegrain 10" (F-10)* $1399.95

ACCESSORIES
788 *Motor Drive* $124.95
790 *LX3 Drive Base* $439.95

Schmidt-Newtonian units have White Fiberlite Tubes
Schmidt-Cassegrain units have Hi-Gloss Blue Tubes
All Units incorporate Fork Mounting & Pier Assembly

Edelman's

PHONE & MAIL ORDERS
Wayne Store Only (201) 227-2515
Daily: 11-7, Sat. 11-5:30

No Hassle/Free Freight Policy. Mention this AD & get Freight Free anywhere in the US VISA & MASTER CARD accepted (add 2 %) COD (add $5.00) Cash or Certified Checks only. - 5% Restocking Fee
Store Hours: *(Both Stores) Daily 10-9, Sat. 9-5:30, Sun. 11-5*

VISA
master charge

AST- 87B

Metro NY. Area - 30 Min. West of NYC
WAYNE N.J.
465 RT. 46, at RTS. 46 & 23
WAYNE N.J. Zip 07470
(201) 256-2071 *or* (201) 227-2515
Phone, Mail Orders & Showroom

Del./Val. Showroom, 5 Min. from Center City
PENNSAUKEN N.J.
RT. 130 So. Airport Circle
PENNSAUKEN N.J.
(609) 665-4244
Sorry No Mail order in Pennsauken

CELESTRON WATERPROOF BINOCULARS

7x50	*Waterproof*
10x50	*Waterproof*
8x30	*Reverse Porro*
10x40	*Waterproof Roof Prism*
8x30	*Waterproof Roof Prism*

YOUR CHOICE **$174.95**

ENJOY ASTRONOMY AT DOWN TO EARTH PRICES

$18 VALUE FREE $18 VALUE
focus ASTROPACK
• Guide to Astronomy
• Astrophotography Basics by Kodak
• Professional Optical Maintenance Kit
w/Purchase of Any Telescope

focus CAMERA INC.
4419-21 13th AVE.
BROOKLYN, N.Y. 11219

FOR ORDERS ONLY
CALL TOLL FREE
800-221-0828
INFORMATION 718-436-6262

Ask for **HELEN, PHIL** or **MARK**, our **TELESCOPE EXPERTS**

FOCUS CAMERA has been serving customers nationwide with all their photographic & astronomical needs for over 17 years. We invite you to join our thousands of satisfied customers. Call our knowledgeable sales staff **TODAY!** and **SAVE!!**

SATISFACTION GUARANTEE: Refund or Exchange within 14 days (less shipping) if returned in original **MINT CONDITION** intact with all papers as shipped.

Authorized Dealer Meade® TELESCOPES & ACCESSORIES
THE LEADER'S EDGE

2080 SERIES SCHMIDT-CASSEGRAIN TELESCOPES

2080 LX3
- Best Seller Astronomical Telescope for the Serious Amateur
- **Quartz Electronic LX Drive**
- Tremendous Light Gathering Capacity
- **Multi-Coated Silvered Optics**
- **AC** or **DC** Operation
- Supplied w/Ultra-Precise Drive System to Automatically Track Astronomical Objects

Outfit includes Star Diagonal, 2 Eyepieces
Super Plössl 9.7mm & 26mm & **8x50 Illuminated Finderscope**
ALL THIS ONLY $1349.80
Complete **w/Electric Drive** Limited Quantities

2080 LX2 **High Transmission Coatings** $1069
2 Eyepieces & 8x50 Finderscope
2080 8" Telescope **w/High Trans. Coating** 889

2080 LX5 NEW! w/2" Visual Back DC Oper. North/South Operation CALL
2120 LX5 NEW! The Ultimate 10" Telescope CALL

NEW MTS SCHMIDT CASSEGRAIN
SC8 8" f/10 With **6x30 Finderscope** Diag. Prism, **25mm Eyepiece,** Per Mount $769
SC8 MCOG As Above w/Silvered Optics $854
SC10 10" Schmidt Cassegrain $1299
#788 Motor Drive f/Mts 119.80
#790 **LX3 Quartz Drive** 419.80

Meade RICH-FIELD NEWTONIAN REFLECTORS
MEADE 8800 8" REFLECTOR
W/Full Equatorial Mount, Slow Motion Controls, 2 Oculars, 102X Power
- Full Length **Tripod** • **Sky Maps**
- **Camera Adapter** 1¼" • 6x30 Finderscope
- **Astrophotography Basics** & Eclipses

9-PIECE OUTFIT VERY SPECIAL $834 ($1490 Retail)

6600 6" Newtonian Reflector Finder, Equatorial Mount & Tripod **LOW PRICE**
8800 8" Reflector w/Tripod 799

CELESTRON® POWERSTAR C8
Complete w/Starbrite Coatings MicroProcessor Quartz Drive, 8x50 Finderscope, 26mm 1¼ Eyepiece, Northern or Southern Hemisphere Drive, **Wedge, Tripod & Wheels, Dew Shield** **COMPLETE FACTORY PACK** $1569

POWERSTAR C8 ACCESSORIES
DEC Motor 48.90 Focus Motor 99.00
AC Adapter 17.25 Car Batt. Adapt. 17.25
Rechargeable Batt. Set 28.90

SUPER C8 PLUS w/SPECIAL COATINGS 17-Piece Outfit w/7mm & 26mm Oculars, 8x50 Finderscope etc. As Supplied By Manufacturer **LIMITED SUPPLY** $847.90
SUPER C8 PLUS STARBRIGHT COATING $1179.80
C8 Tripod 198 C8 Wedge 77
SUPER POLARIS C8 11-Piece Outfit w/Tripod, Limited! 895
SPC8 STARBRIGHT As Above 1029
C11 STARBRIGHT 3199

LIMITED QUANTITIES
FIRSTSCOPE 80 6-Piece Outfit
80mm Ultra-Sharp Optics 410mm Focal Length, Complete w/35X Eyepiece, 1¼" Star Diagonal Alt-Azimuth Mount w/Slow Motion Controls, Field Tripod w/Tray $369

C80 **80mm Equatorial Refractor** w/Finderscope, 36X & 152X E.P., Tripod **ONLY FIVE PIECES LEFT!** $399
SPC80 w/Super Polaris Mount CALL
SCP6 **6" Newtonian,** 750mm f/5 Optics Super Polaris Mount, Complete $695
CO-60 COMETRON REFRACTOR, Best Value, w/2 Eyepieces & All Accessories 78.70
COMETRON 50 Solid Brass, Executive Style w/Pedestal, 40 Power 168

NEW MTS SCHMIDT-NEWTONIANS
SN6 6" f/5 **Schmidt Newtonian Reflector** w/Pier Mount, Legs, 25mm Eyepiece $529
SN6 MCOG As Above w/Silvered Optics $589
SN8 8" f/4 Schmidt Newtonian Reflector $779
SN8 MCOG w/Silvered Optics CALL
#66A Declination Control 6" $49
6x30 Finderscope $49

DEEP-SPACE TELESCOPES
DS-10A 10" f4.5 Ultra-Sharp Reflecting Telescope w/Motor Drive, Setting Circles and Deluxe Focuser $839
DS-16A 16" Reflector. Gathers 4 Times as Much Light as an 8" Scope! Includes Motor Drive, Focuser & 1¼" Eyepiece $1789

Meade SPOTTING SCOPES
A WHOLE LOT MORE THAN MEETS THE EYE!
LIFETIME WARRANTY
w/5X24 Viewfinder, Astro Photo Book
97D Metal System Carry Case $307
- 1000mm Effective Focal Length
- 49X More Brightness Than The Human Eye
- 40X & 83X Eyepieces Included

97ER Erect Image (Right-Side Up) Black Rubber Covered Spotting Scope 397
107D w/40X Ocular, 1000MM Effect, 4" w/Finder CALL
107D w/Photo Tripod 387
PATHFINDER 15X-60X Zoom, 14 Elements, Razor Sharp. Same w/Rubberized Coating 242 309

MEADE REFRACTORS:
310 3.1" 80MM F11, 1¼" Accessories 384
320 3.1" **80mm Equatorial** $539

Meade ACCESSORIES:
#38 Dec. Motor (2080 LX3) 86
#38A Dec. Motor (2045) 86
45° Erect Prism 1¼" 44
Dew Shield (2080, MTS SC8) 58
Illuminated Reticle 85
Camera Adapter 34
#36 Control 87
#43 RA Motor (MTS) 88
#1200 Elec. Focus 152
T-Adapter (MTS SC8, 10) 39
Tele Extender 29
Other MTS Acces. CALL

Meade EYEPIECES:
Super Plössl 1¼" 6.4, 9.7, 12.4, 15, 20, 26mm 74.50
Barlow Lens 2X, 2.8X 73
Superwide 1¼" 13.8, 18, 24.5, 32, 40 From $113

COMET CATCHER JR.
5-Inch, 1000mm Reflector
320X Light Gathering Than The **Human Eye!**
w/**40X Eyepiece** & **6X30 Finder**
PERFECT BEGINNERS SCOPE!
SUMMER SALE! $147
Deluxe Tripod f/Com. Cat. Jr. 57

COMET CATCHER **5.5" Richfield** Schmidt-**Newtonian, F3.6** Optics $248.00
Complete with 18mm 1¼ Eyepiece

C90 SPOTTING SCOPE
- Powerful and Versatile
- Can Be Used as Telescope or Telephoto Lens
- 159X The Light Gathering Ability of the Human Eye

$20.00 OFF Tripod w Purch
C90 7-PIECE OUTFIT INCLUDES:
- 30mm Ocular • Finderscope • Hi-Tech BLACK • Carry Case
- 18mm Ocular • Star Diagonal • Accessory Catalog • Lens Cap

C90 ASTRO 488 **SUPER C90** 409
C90 Rubberized w/Tough Rubber Coat. Uses 1¼" Acces. 434
SS-50 Spotting Scope w/20X, Hi-Tech Black **Special** 79
Photographic Tripod For **C90, Special** 68

ACCESSORIES
Accessory Case 29.50
Barlow **2, 2.5, 3X** • 96" @ 33
Barlow **2X, 3X** 1¼ @ 41
Counterweight Bar ASS. 8" 95
DC Inverter 98
Dewstar/Shield 8" 25.70
Drive CRCTR (SA) SPC 127
EP Filter Set • 96" 52
EP Filter Set 1¼" 72
10X40 Finder C8 112
Illum Reticle 1¼" 157
Image Corrector 1¼" 38
EYEPIECES:
Orthoscopic • 96" 4, 5, 7, 9, 12mm @ 41
Orthoscopic 1¼" 4, 5, 6, 7, 9, 12, 18, 25mm @ 42
LPR #1 109
LPR #3, 4 @ 67
Optics Cleaning Kit 27
Porro Prism • 96" 29
Porro Prism 1¼ 37
Rich Field Lens 28
Sky Maps 14
Sky Sensor LOW PRICE
Sky Filter #1 (C90) 35
Sky Filter #2 (C8) 38
Tele Extender 28
Wedge (C90) 77
Ploss l 1¼" 7.5, 10, 15, 17, 22, 26, 36, 45mm @ 67
Erfle 1¼" Wide Field 16, 20, 24, 28, 32mm @ 54

BAUSCH & LOMB CRITERION
4000 ASTRONOMICAL OBSERVATORY TELESCOPE
BUY SOMETHING WORTH LOOKING INTO!
- Compact 7"x7"x14" weighs 10 lbs.
- Includes Finderscope, 2 Oculars & Adjustable Legs
- 1200mm Effective Focal Length
- With Electrical Clock Drive

9-Piece Outfit $443

BAUSCH & LOMB 4000 PRO Observatory Telescope w/2X Barlow, Camera Mount and Enhanced Optical Coating for 20% Greater Light Transmission 499
B&L 4000 Spotting Scope w/30X & Porro Prism 335
CRITERION 3000 Spotter NEW! 189

CRITERION 8001 OBSERVATORY
- 8" Aperture
- 2110 MM F/10 Focal Length
- 480X Magnification
- 2 Oculars
- Deep Sky Guide
- 8x50 Finderscope

999

CRITERION 6000 PRO Astronomical 6" Scope **10-PIECE OUTFIT**
As Above w/6" 1400MM Focal Length CALL

TELESCOPE ACCESSORIES:
Wedge (4000) 68
Field Tripod (4000) 132
Porro Prism (4000) 38
2X Barlow Lens 28
Solar Filter (4000) 97
4000 Astro Photo Kit (4 Pcs.) 69
Wedge (6000/8000) 78
Field Tripod (6000/8000) 190
Nebula Filter 63
Counterweight Set 39
Video C-Mount 32

NEWTONIAN REFLECTORS
4.5" Reflector w/Tripod & • 96" E.P. 329
RV-5+ w/Tripod Equatorial Mount Finderscope & 3 1¼" Eyepieces 649

BAUSCH & LOMB
Discoverer Zoom Telescope
Spotting Scope w/15X-60X Zoom 189

ASTRO TELESCOPES
#5400 155X Magnification, w/Finderscope & Tripod 99
#5500 Same w/280X Magni. 124
#5100 Features 400X Magni. 159
Camera Mount 18.90
Bushnell Discoverer Case 26
Car Window Mount 34
Proff. Photo Tripod 59

SPACEMASTER® PRISMATIC TELESCOPES
- SPACEMASTER 60MM
- 15-60X Zoom Eyepiece
- Mini Tripod
- Attaché Case

4-PC. OUTFIT 217

SPACEMASTER #1800 145 Camera Mount 27
Eyepiece 35 Zoom 75 Wide-Angle 42
#2300 45° SPACEMASTER 178 Case 19

GIANT BINOCULARS
CELESTRON® UNITRON® Meade PRECISION OPTICS

- Perfect for Astronomy & Low Light Viewing
- Glare-Free Viewing & No Eyestrain
- Exceptional Image • 25 Yr. Warranty

11x80 209 20x80 229
30x80 CALL
16x70 Astro Observation 323
20x80 Deluxe Multicoated w/Sliding Rail. 415
11x80R **Rubberized** 239 20x80R **Rubberized** 259
Tripod Adapter 18.90

NEW ASTRONOMICAL SOFTWARE BY ZEPHYR
The Easy Way To Do
ASTROCALC- Those Difficult Calculations 29.90
View the Constellations
ASTROSTELL- & Their Treasures 29.90
ASTROBASE- A Data Base For Astronomers 29.90
ASTRO-AID- Gives You The Answers 29.90
COMETWATCH Complete Details About Comets 29.90
Available For IBM, Apple & Commodore C64/128
BONUS BUY ANY TWO PROGRAMS **SAVE 10%**

SPOTTING SCOPES & BINOCULARS
Nikon *The Famous Nikon Optics Are Your Best Assurance For Clear And Crisp Images*

NIKON SPOTTING **SCOPE w/20X** 247
Nikon Spotting Scope **ED** CALL
Photo Attachment 114
7x50 Center Focus 'Starview' 133
7x35 CF w/25 Yr. Warr. 79
7x50 Tropical 197
8x23-CF 75 10x50 Sentinal. 153
10x70-IF 378
12x36D 227

Bushnell BINOCULARS
BAUSCH & LOMB SERIES:
7x35 CF #61-2010 209
10x50 CF Standard 224
7x24 149 8x24 159
EXPLORER SERIES:
7x50 Insta-Focus 114
8x40 Wide Angle 114
10x50 Wide 119
BANNER SERIES:
7x50 Instafocus 74
10x50 Wide 77
8-24x50 Instafocus Zoom. 136
SPORTSVIEW:
7x35 Extra Wide Angle 44
7x50 45 10x50 50
8x40 Wide 52 16x50 58

focus CAMERA
4421 -13th Ave.
Brooklyn, N.Y. 11219
ORDERS: 800-221-0828
INFORMATION: 718-436-6262
CUST. SERVICE: 718-871-7608

Orders Shipped Promptly—Mastercard, Visa & **Discover** gladly accepted. You may use your American Express card. No surcharge on Mastercard, Visa or **Discover.** Please add estimated charge for re-shipping, handling & insurance. Written inquiries welcome. Not responsible for typographical errors. HOURS: Mon-Thurs 10-7, Fri 10-4, Sun 10-6. All merchandise available at prices shown while supplies last. This ad supercedes all other ads.

All Telescopes include Full U.S.A. Warranty, and are Shipped Complete as Packaged by the Manufacturer.

THE STARRY MESSENGER

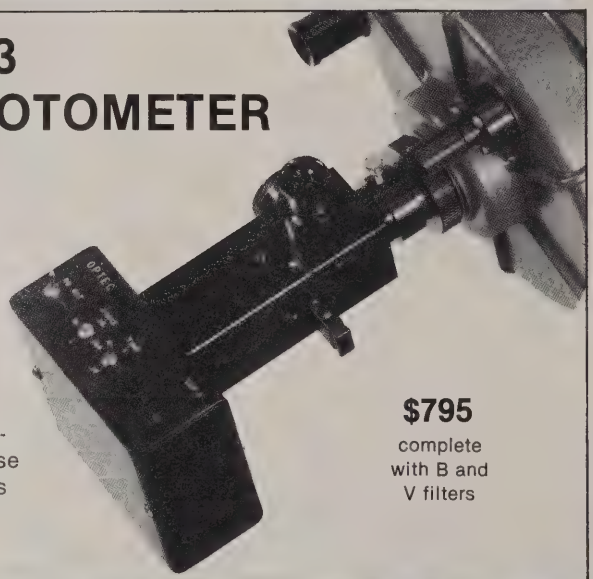
TSM still delivers more astronomy classified advertisements than any publication in the world because it's *FREE* to advertise in **TSM**. Each month **TSM** brings you *HUNDREDS* of the most current ads for scopes, eyepieces, accessories and other astronomical bargains. To subscribe to **TSM** or place a free ad, simply write us or call 201-992-2192 (9 am - 11 pm EST).

Free with your paid subscription:
1987 TSM Buyers/Sellers Guide to Used Equipment Prices

12-issue subscription $15
Single issue price ..... $ 3

THE STARRY MESSENGER PO Box 4823-S, Ithaca, NY 14852

MODEL SSP-3 STELLAR PHOTOMETER



FEATURES:
- UBVRI Johnson standard filters
- 9-volt battery or AC operation
- 4-digit display
- external computer or chart recorder interface
- ultra-sensitive silicon photodiode detector allows precise measurements of faint stars
- all-metal construction — built to last

$795
complete with B and V filters

OPTEC, Inc.
manufacturer of the SSP photometer series for 11 years
199 Smith • Lowell, MI 49331 • (616) 897-9351
literature on request
27-page manual $4.00 ($6.00 foreign)

TURNKEY RESEARCH SYSTEMS

by AutoScope

STANDARD FEATURES

- –.50 or .75 Meter Telescopes
- –PC Based Control System
- –Automatic Photometer
- –Automatic or Manual Telescope Operation
- –Control/Reduction Software Package

OPTIONS

- –Observatory Control for Unattended Operation
- –Remote Access Photometry
- –Automatic Telescope Enclosures
- –Intensified CCD Camera
- –Installation

For more information contact AutoScope at: 1313 N. Rosemont Drive Mesa, Arizona 85205.

Once in a lifetime

Around the World with the...
Official Halley's Comet Postage Stamp Collection

CAPTURE THE MOMENT!
The Complete Set (Part 1, 21 Countries)
You may order this entire collection at once or subscribe monthly. When ordering monthly, you'll receive complete sets of mint stamps, which include many high value denominations as well as a beautiful first day cover, to add to your handsome album (provided free with your subscription). This is an exceptional value at only $29.95 a month.

Experience the beauty and majesty of a collection whose historic and investment value will last forever!

Please reserve Part I of The Official Collection (21 countries and deluxe album).
☐ Enclosed is $29.95. Bill the balance in 11 installments of $29.95.
☐ Enclosed is full payment of $323.46 for this Complete Set (10% discount off 12 month subscription rate)
Sampling:
☐ Enclosed is full payment of $27.50 for Select Sampling mounted in a 5x7 Protective Leatherette Cover.
Send me the above, but charge my credit card
☐Visa ☐MasterCard Card No _____
Exp. Date_____ Signature _____
Name _____
Address _____
City_____ State/Zip_____
Mail to: ***Philatelic Collectors, Inc., Box 224 SK***
Valley Stream, NY 11582 (516) 825-5514
N.Y. state residents add 8% tax. Subscription may be cancelled at any time. All orders subject to availability. 30 day money back guarantee.

Gleanings for ATM's

Conducted by Roger W. Sinnott

PROGRESS AND PANIC AT PUIMICHEL

ALMOST nine years ago, Belgian amateur Dany Cardoen described his massively mounted 16-inch reflector in this magazine (*S&T:* February, 1979, page 185). "In view of the ease I found in grinding this large mirror by hand, I am now hatching plans to make a 1-meter (40-inch) mirror," he wrote prophetically.

The idea remained pretty much a dream for several years thereafter. But Dany and his friend Arlette Steenmans, an amateur astronomer and artist, began to visit sites in Germany, France, and Spain. Their immediate goal was simply to relocate the 16-inch reflector outside the light-polluted skies of Belgium. On one trip they discovered Puimichel, a small village in southern France 15 miles east of the famous Haute Provence Observatory. The area has one of the best climates in central Europe for astronomical work.

At Puimichel they found the remains of an old farm for sale. The house was in serious disrepair, just four walls and no running water. And though they had no steady income Dany and Arlette purchased it and moved in — Puimichel Observatory was born.

Dany began to make custom telescopes, heavy-duty equatorial mountings, and solar-prominence instruments to raise the money needed to rebuild the farmhouse. He and Arlette also took odd jobs in the village. Visits from Flemish and Dutch amateurs encouraged them in their struggles with French officialdom. My wife and I spent part of our honeymoon there.

"Imagine our surprise when 1,100 pounds of chocolate arrived instead of the 42-inch disk!"

Soon they founded the Association Newton 406 — named for Dany's original

It would have ranked among the largest telescope mirrors ever made by amateurs. But now Dany Cardoen and Arlette Steenmans, recently married, use it as a 42-inch garden table at their amateur-run Puimichel Observatory in southern France. The sudden, mysterious crack that doomed the blank proved to be only a temporary setback in their project, however. A new 42-inch blank of low-expansion Zerodur glass was purchased, and it is now in the final stages of figuring. All photographs with this article are by the Swiss amateur Gerhart Klaus, who also supplied important recent details.

TELESCOPES AND INSTRUMENTS

These books will guide you from making your first telescope to making spectrohelioscopes for observing the Sun, and more!

Binoculars and All-Purpose Telescopes
— Paul *35581* **$11.95**
For the beginner considering a purchase. *96 pages, hardbound.* (Level 1)

Build Your Own Telescope
— Berry *84761* **$24.95**
Complete plans for making five telescopes using readily available materials. Many telescope making books assume you have some shop experience; this is for true novices. The cheapest and most rewarding route to telescope ownership. *276 pages, hardbound.* (Levels 1-2)

Making Your Own Telescope
— Thompson *46123* **$9.95**
For four decades *Making Your Own Telescope* has been a favorite manual for amateur telescope makers, with its clear text and complete instructions. It details every step of how to build a traditional 6-inch reflector, a project which requires only willingness, patience, and readily available materials. *An SPC publication! 211 pages, hardbound.* (Levels 2-3)

Sundials — How To Know, Make, and Use Them
— Mayall & Mayall *46115* **$12.95**
The design and workings of solar timekeepers. 2nd edition. *250 pages, hardbound.* (Levels 1-2)

How To Make a Telescope
— Texereau *96042* **$19.95**
A very thorough guide for over 30 years; revised in 1984. *424 pages, hardbound.* (Levels 2-3)

Advanced Telescope Making Techniques
— Mackintosh
Nearly 20 years of the *Maksutov Club Circulars* covering all aspects of telescope making have been edited down into this two-volume set. Hundreds of little-known ideas and techniques. Each volume is about 320 pages, softbound. (Level 3)
Vol. 1 — Optics *96115* **$19.95**
Vol. 2 — Mechanical *96123* **$19.95**

The Telescope
— Bell *41513* **$6.95**
Reprint of a classic 1922 work that's still of interest to telescope makers and owners. *287 pages, softbound.* (Levels 2-3)

The Adjustment and Testing of Telescope Objectives
— Taylor *4756X* **$17.00**
A standard work on refractor lenses for many decades: making, testing, aligning, and cleaning them. *101 pages, softbound.* (Levels 2-3)

Level 1 = beginner, Level 2 = intermediate amateur, Level 3 = advanced. Use the order form in the center of this issue. Your order is shipped postpaid in the U. S.!

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, Mass. 02238-9102

DAYSTAR
HYDROGEN-ALPHA SOLAR FILTERS

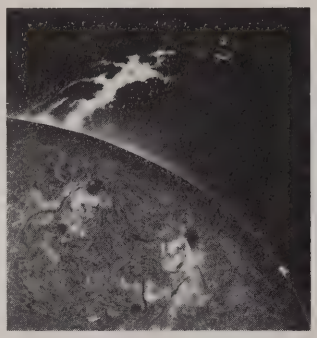


Photo by Edwin Hirsch

NEW
LOW COST
MODEL
T-SCANNER

REGULAR
ATM
MODEL

Edwin Hirsch, well known to astronomers for his remarkable filtergrams of the Sun taken with the famous DAYSTAR H-alpha Solar Filter, shows our Sun and its thousands of faces of ever-changing detail. See plage, filaments, sunspots, magnetic lines, prominences and the cataclysmic explosions of solar flares in the chromosphere.

CELESTRON®
Computer controlled telescopes.
SUPER C8″+ **POWERSTAR 8″**
Complete telescope line
and accessories.

Meade®
THE LEADER'S EDGE
2080LX5 **2120LX5**
Complete telescope line
and accessories.
Authorized Meade Dealer

Tele Vue®
NEW!* ORACLE 3″ *APOCHROMAT
RENAISSANCE 4″
PLÖSSL–WIDE FIELD–NAGLER
Eyepieces

***NEW!* SAFARI 14**
The portable 14″ Dobsonian that fits
in the back of your car

MOTOFOCUS
Auto focusers and declination motors
for most telescopes.

ATI THE CAT
Computer aided telescope
programmed for 8300 *objects*

Let my expertise guide you in your next adventure in astronomy.
LOW PRICES – FREE ADVICE

SEE FULLY COMPUTERIZED CELESTRON 14″ IN ACTION
Demonstrations in my observatory.

Edwin Hirsch
168 LAKEVIEW DR., RR2
TOMKINS COVE, N.Y. 10986
(914) 786-3738

16-inch (406-mm) reflector. This organization now runs the observatory as an amateur astronomers' holiday resort and research center. Many European amateurs belong to this association, whose activities have grown spectacularly over the last few years. In the summer of 1985 alone, some 200 amateurs came from all over Europe to observe at Puimichel.

THE 42-INCH GIANT

Once they had decided to stay in southern France, Dany and Arlette began looking for a 1-meter glass disk. A new one would have been expensive, so they wrote to professional observatories in hopes of finding something secondhand.

The noted German publisher Hans Vehrenberg and Swiss astrophotographer Gerhart Klaus were key players in this search, eventually locating an unused 42-inch disk in the United States. It was owned by computer expert and amateur optical designer Mike Simmons, then living in Arizona. He agreed to sell the blank, which had been used as an optical flat by the firm of Warner & Swasey decades ago to test their large telescopes. The disk was to be flown to Paris.

Imagine the surprise, shortly thereafter, when 1,100 pounds of chocolate arrived instead! The problem was traced to a shipping error at Chicago's O'Hare International Airport. A few weeks later the gigantic glass blank finally made it across the Atlantic in good condition. It went by truck from Paris to Puimichel, where Dany placed it on the 18-point flotation system of a homemade grinding machine.

DISASTER STRIKES

Taking every possible precaution, Dany began to work on the large disk in its face-up position. Two curved rails carried a rotating grinding tool back and forth across the surface. A very short-focus f/3 telescope was planned, so over 600 cubic inches of glass would have to be removed to reach a curve depth of 0.83 inch. This would take many weeks of rough grinding alone.

At first all went well. But one morning Dany entered his shop and was con-

Left: The telescope's gigantic horseshoe mounting, fabricated in Belgium by Cardoen's brother Patrick, is already inside the dome at Puimichel and ready to be installed in the sunken concrete floor.

Below: A few hundred yards from the village of Puimichel, this 20-foot dome sits on a hill donated to the Association Newton 406 by Raymond Yves. Soon the 42-inch reflector should be fully operational at this idyllic site, where more than half the nights in any year are clear and the snow-capped French Alps rise in the distance.

fronted by every glassworker's nightmare. The disk had mysteriously split in half! The boundary between the two segments was a symmetrical wavy line. At least the calamity occurred when no one was around, rather than during some accidental mishandling — a small consolation.

Naturally the disappointment was very great, but at no time did the dream of a 1-meter telescope fade. Dany's brother, Patrick Cardoen, had already constructed a huge Palomar-type horseshoe for the equatorial mounting. A 6-meter dome was also in place, to protect the telescope from the strong mistrals that sweep across the region. While these winds often annoy observers, they bring us about 200 clear nights a year.

After the accident, the association intensified its fund-raising efforts. A replacement blank of Zerodur was purchased, and Dany is already well along in finishing it to the same specifications as the original mirror. A vacuum chamber, donated by a

Left: The pitch lap used to polish the Zerodur blank is covered with newspaper to protect it from dust. Like grinding, all polishing and figuring are done with the mirror face-up. *Right:* The new 42-inch Zerodur mirror, seen in this Klaus photograph taken last June, was fully polished after only 25 hours of work with the pitch lap. All that remains is parabolizing. Without being removed from the polishing machine, the mirror can be swung to a vertical position for examination of its figure. From his earlier experience making a highly accurate 20-inch mirror for Jura Observatory in Grenchen, Switzerland, Cardoen prefers the caustic and wire tests.

PRECISION PRIMARY MIRRORS

THE FINEST NEWTONIAN OPTICS AVAILABLE. EACH IS INDIVIDUALLY HAND-FIGURED AND TESTED UNDER AUTOCOLLIMATION. QUALITY FINE-ANNEALED OPTICAL PYREX. 1/8TH WAVE.

SIZE	AL COATING 90% REFL	ENHANCED COATING 96% REFL
6"f/6 or f/8	$ 99.00	$ 129.00
10"f/4.5 or f/6	$ 169.00	$ 229.00
14¼"f/4.5 or f/5.6	$ 329.00	$ 429.00
17½"f/4.5	$ 689.00	$ 829.00

ELLIPTICAL MIRRORS

FLAT TO 1/10th WAVE. FINE-ANNEALED PYREX. INDIVIDUALLY HAND FIGURED. 96% REFLECTIVITY ENHANCED COATING.

1.33" - $ 29.00
1.55" - $ 34.00
1.83" - $ 39.00
2.14" - $ 45.00
2.60" - $ 59.00
3.10" - $ 79.00
4.00" - $ 229.00

PROFESSIONAL OCULARS/AFFORDABLE PRICE

ORTHOSCOPICS - 1¼"
6mm, 9mm, 12.5mm, 18mm, 25mm - $36.00ea
BARLOW'S - 1¼" 26mm CLEAR APERTURE
2X or 3X $29.00 ea

TELE VUE EYEPIECES

MANUFACTURERS OF PRECISION OPTICS UP TO 24" DIAMETER

PLEASE SEND $1 00 FOR OUR CATALOG

• PRECISION FLATS • ALUMINUM AND ENHANCED COATINGS • REFIGURING • SUPPLIES • TESTING • COMPONENTS

SKY OPTICAL
12428 GLADSTONE ST., SYLMAR, CA 91342
(818) 361-6576

TELESCOPE REPAIR AND RESTORATION

Many fine telescopes are now useless for want of repair. Mold, mildew, dust, and dirt collect on objective lenses and mirrors and in eyepieces and finders. Other problems include corrosion, frozen bearings and focusers, burned-out clock drives, lost or broken parts, to say nothing of damage caused by accidentally knocking the scope over.

We have over 35 years of experience with telescopes from Dollond to Questar. Reflector, refractor, Schmidt-Cassegrain and Maksutov catadioptric, Cassegrainian or Gregorian, antique or modern; no job is too large or too small. Every instrument is star-tested and all work is, of course, guaranteed.

Call or send your name and address for a free repair-estimate form. Upon returning the completed form to us we will advise you of the cost of the repair. You are under no obligation

PHOTON INSTRUMENTS, LTD.
30 KING STREET (516) 331-3869
PORT JEFFERSON STATION, NY 11776

★ ENHANCED MIRROR COATINGS ★

Enhanced Aluminizing—96% average reflection.
$5.25 per inch of diameter up to 12.5".
$8.50 per inch of diameter up to 18.5".

Regular Aluminizing—90% average reflection.
$2.50 per inch of diameter up to 12.5".
$3.75 per inch of diameter up to 18.5".

Diagonals Coated FREE!!

NO CHARGE TO REMOVE OLD COATING IF YOU MENTION THIS AD. SAVE $5.00.

Send mirror with return shipping and insurance.
QUALITY WORK GUARANTEED

P.A.P. COATING SERVICES
1112 CHATEAU AVENUE
ANAHEIM, CA 92802
(714) 535-4460

university, will be used to aluminize the mirror in-house. Eventually, the telescope will have a Wynne corrector to widen its photographic field, and a spectrograph.

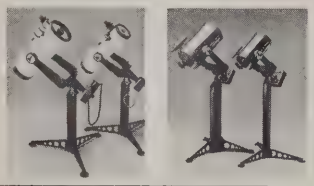
For part of the time, the 42-inch telescope will be made available to professional astronomers. Those at smaller institutions often have trouble getting observing time at national observatories. We believe Puimichel can become a worthwhile alternative for them in these times of worldwide budget-cutting in research. We'd especially like to hear from astronomers who think they can help our cause by donating unused equipment.

We will also cooperate with local high schools and offer students a chance to gain hands-on experience in this extraordinary branch of science. Puimichel promises to be an ideal place for advanced amateurs to do scientific work, too.

Even those who merely dream about seeing Saturn or Messier 13 through a 42-inch telescope are invited to write to the undersigned. And if anyone is interested in helping us financially, he or she should not hesitate to contact Association Newton 406, La Remise, Puimichel, 04700 Oraison, France. A rather heavy garden table is up for sale.

LUC VANHOECK
Breendonkdorp 83
2659 Puurs, Belgium

Catalog Package & Buyer's Guide, $3
Meade® THE LEADER'S EDGE



We Will Not Be Undersold
Check with us prior to making any purchases
WE HAVE IT ALL!

MTS-SC8 MTS-SN8
MTS-SC10 MTS-SN6
CALL

Proudly made in U. S. A. by U. S. A. manufacturer.

Paul's D/B/A Discount Optics
29 Kingswood Road
Danbury, CT 06811
(203) 746-3579
MasterCard VISA
3% credit charge
6 DAYS • 9am-6pm DST
Established 1914

Experiments with a Toothless Sector

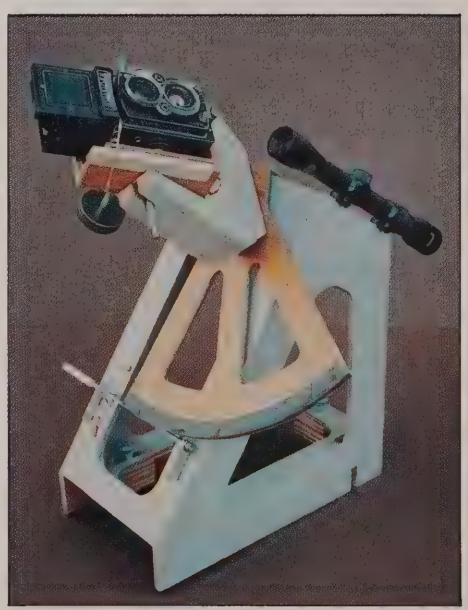
IT MUST appeal to human nature to make a camera track the stars by hand power, without electricity. Witness the growing popularity of hand-driven barn-door camera mounts. But I resisted the temptation to build one of these because of their inherent tangent error. Exposures must be kept fairly short; otherwise, star images will not be small and round but elongated on the film.

The error arises when the linear motion of a screw-driven nut is converted to angular motion around a polar axis. Specially shaped cams and variable-speed nuts are just some of the clever refinements that can avoid tangent error. However, I decided on a completely different and far simpler drive with no tangent error at all: a worm and sector. My idea was to use a piece of ordinary threaded rod for the worm, and to mold teeth on the sector's rim by making an impression in epoxy cement that had partially set.

Preliminary experiments were encouraging. But I abandoned the idea of epoxy teeth when I found, following a hunch, that the sector would track accurately and smoothly with no teeth at all! Apparently the sharp metal threads bite into the sector's softer Masonite material, giving more than enough traction to drive the camera.

At first this seemed too good to be true. I spent considerable time making pencil marks on the sector and confirming that the marks tracked faithfully opposite the turning thread. In practice, it helps to line the sector with two layers of masking tape, thus forming a good base for the worm to cut into and saving wear on the sector itself.

The computations to determine the radius of the sector are simple. Let's assume we want to turn a small crank in unison with the second hand of a watch. The worm, then, rotates at 1 r.p.m. A full turn of the worm will advance the rim of the sector a distance equal to the individual thread spacing. Since there are about 1,436 minutes in a sidereal day, the circum-



Three views of David Harbour's camera mount. The riflescope mounted parallel to the polar axis is used to orient the mounting toward the celestial pole. Then, star tracking is as simple as turning the threaded rod once every minute. An observer in the Northern Hemisphere must turn the crank clockwise, while one in the Southern Hemisphere would turn it counterclockwise. The toothless Masonite sector has curved strips fastened along the arc to keep the threaded rod squarely in position. Two bolts in a slot near the crank allow the rod to be disengaged, as shown in the view at top left. All photographs are by the author.

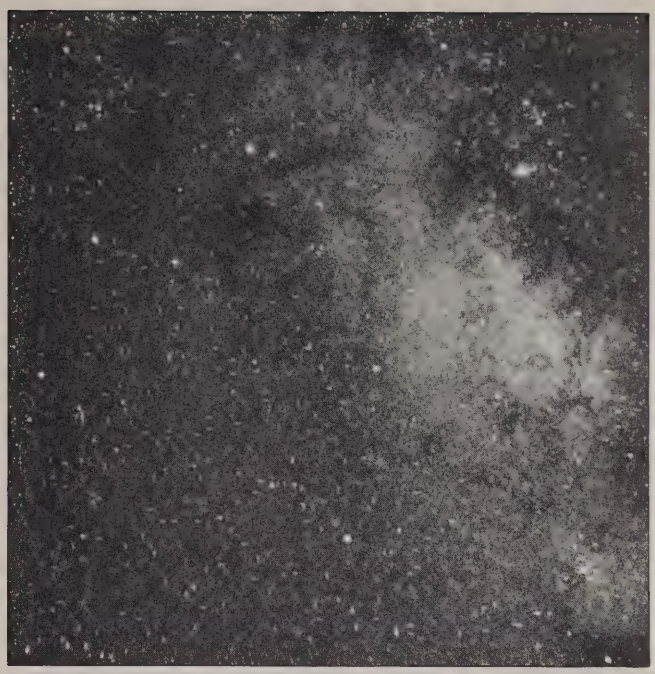
ference of the circle to which the sector belongs must be 1,436 times the spacing of the threads.

If the shaft has a pitch of 20 threads per inch, the required circumference is 71.80 inches. Dividing by 2π, or 6.28, gives 11.43 inches for the sector's radius.

I added my sector drive to a tabletop equatorial mounting that I made of ¼-inch plywood. Its polar axle is a ½-inch-diameter carriage bolt from a hardware store. The "bearings" are two simple steel plates, each with a deep V notch in one edge. The northern plate sits underneath the polar axle, supporting the weight. The southern one is placed above the polar axle so that it can resist the axle's upward thrust at that end. Each plate touches the smooth (unthreaded) part of the bolt.

A close-up of the south polar bearing — a simple V notch in a steel plate. The north bearing is identical, but it supports the shaft from underneath.

A wooden box riding in a small fork carries the camera, as the photographs show. Masonite shims, cut for the purpose, adequately secure any one of several cameras I own. The very first exposures I made with this setup showed no tracking error. (Instead, they indicated that my old f/1.5 Voigtlander Nokton lens must be stopped down! I wonder how a manufacturer could have offered a lens with such



Assisted by his friend Terry Anderson last August 29th, David Harbour used the toothless sector for this 15-minute exposure of Sagittarius on Kodak T-Max film at f/2.8. At lower right is the brilliant star cluster M7, while the Teapot's handle stands out at left center. The star-studded cloud toward upper right is the Lagoon nebula, M8. Just above and left of center lies M22, the third brightest globular cluster in the sky. With the finder chart on page 67 of last January's issue, it's possible to pick out 8th-magnitude Neptune only 16 mm from M22, toward 2 o'clock.

CHRISTMAS SPECIALS!

NOW THROUGH DECEMBER 31st, 1987

MEADE • CELESTRON
TELE VUE • Space Systems

CALL OR WRITE FOR OUR **FREE** CHRISTMAS CATALOG
WITH COMPLETE LISTINGS, PRICES, and ORDER INFORMATION.

FOR EXAMPLE:
MEADE 2120/ LX3
AS LOW AS
$1829.00
EXTRA SPECIAL PRICING ON 2120/LX5 TOO!

CELESTRON SPC80
ONLY $579.00

MEADE 107D
ONLY $300.00

TELE VUE 20mm NAGLER
$299.00

SUNWEST SPACE SYSTEMS, INC.
P.O. Box 20500
St. Petersburg, FL 33742
Telephone: (813) 577-0629

WE HAVE:
NEW • USED
LEFTOVERS
ODDS & ENDS
TELESCOPES
BINOCULARS
SPOTTING SCOPES
MOUNTS
TUBE ASSEMBLIES
ACCESSORIES

Professionals in Business for the Amateur Astronomer Since 1979.
LIMITED QUANTITIES

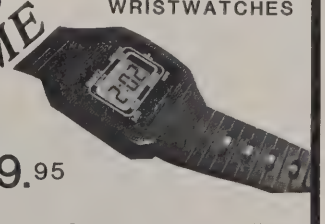
ASTRO WORLD

Telescopes and accessories
Stocking dealer for:
Celestron — Meade
University — others

Complete machine shop
Hundreds of items on display
New and used equipment
Competitive prices
Our 16th year

5126 Belair Rd.
Baltimore, MD 21206
301-483-5100 Send S.A.S.E. for Price List

IT'S ABOUT TIME
SIDEREAL
WRISTWATCHES



$29.95
30 Day refund privilege
GEMINI
24 hr. Sidereal watch
8930 Blue Smoke Dr. (301) 921-0157
Gaithersburg, MD 20879

tremendous aberration at the edge of the frame.)

As Roger Tuthill noted many years ago, standard threaded rods of the type sold in hardware stores are rolled rather than cut with a die and thus have high accuracy (*S&T:* July, 1972, page 47). I believe a larger, more robust version of this kind of drive would work well for a small- to medium-size telescope. The most attractive features of this "toothless" sector are its ease of construction and low cost, even when made large.

DAVID A. HARBOUR
2321 C. Court
Enid, Okla. 73703

Astronomical & Scientific
BOOKS
NEW! URANOMETRIA 2000.0
Volume 1 ..... $39.95
ASTROPHOTOGRAPHY FOR THE AMATEUR
By M. A. Covington $24.95
ASTROPHOTOGRAPHY, STEP BY STEP APPROACH By R.T. Little $19.95
ASTROPHOTOGRAPHY
By B. Gordon $18.95
CHECK A POSSIBLE SUPERNOVA
Part I, Part II; 40 photo cards (each) of galaxies, spiral bound for field use ..... @$6.25
BURNHAM'S CELESTIAL HANDBOOK
Volumes 1,2,3 ..... $36.95
ASTRONOMICAL ALMANAC for 1988 ... $21.00
Send for our complete FREE list of books.
Herbert A. Luft
P.O. Box 91—Oakland Gardens, N.Y. 11364

Optical Bench Talk

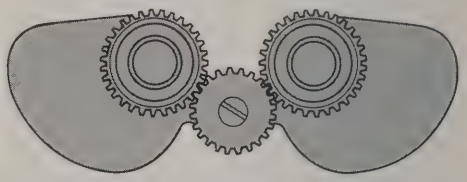
Blackening a tube. "I have found a very inexpensive way to change the inside of a baffle tube, or even the main tube of a telescope, from dark to *black,*" writes Carl Buzzard of 3081 Lynnwood Ct., Streamwood, Ill. 60107. "Start with a coat of Rustoleum flat black paint, which is already fairly high in carbon content. While the paint is still wet, sprinkle it liberally with sawdust.

"Allow the paint to dry thoroughly, at least 24 hours. Then apply a second coat of paint, with a patting action of the brush rather than back-and-forth strokes. This will reduce the amount of sawdust brushed off. When the second coat dries, the surface will be very tough and durable. It may require touching up in places to cover the sawdust completely.

"The result is a surface with extremely small reflectivity for glancing light. Furthermore, sawdust is easier to obtain than flocking and just as effective, if not more so. People who don't have any sawdust of their own can surely get some at a local lumberyard for free."

Center-focusing binoculars. "The general public has been 'educated' into the belief that a properly made binocular should have a central knob, the turning of which moves the oculars inwardly and outwardly simultaneously," wrote G. Dallas Hanna in A. G. Ingalls' *Amateur Telescope Making — Book Three.* "This design is unsound." Hanna then extolled the superior rigidity and freedom from collimation problems of binoculars with individually focusing eyepieces.

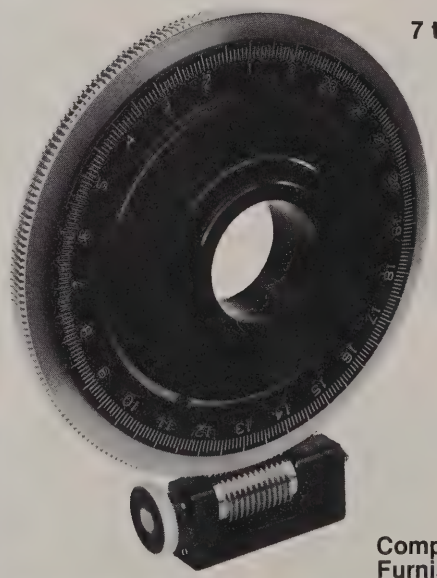
However, an apparently novel idea has occurred to Harold M. Benson of 2104 Pershing Ave., Davenport, Iowa 52803. Instead of the clumsy "eyepiece tree" of a typical center-focusing design, he proposes to use a spur gear that engages ring gears on the eyepieces:



Turning the central shaft will then move the eyepieces in unison, either in or out, on threaded barrels. This arrangement has none of the inherent play of sliding tubes. The gears remain meshed at any interpupillary setting, because the eyepieces stay the same distance from the hinge pin.

"Is there something wrong with this idea that hasn't occurred to me?" asks Benson, a longtime enthusiast who has made several giant binoculars himself. "If not, why isn't it in use?"

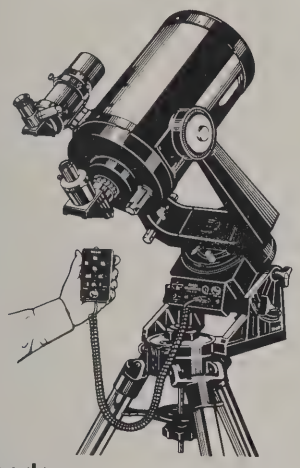
OBSERVATORY FORK MOUNTINGS
Designed for
10- to 20-inch Compact
Optical Systems

Permanent Installations
Instrument Platforms
Computer Controls
COMPLETE DRIVE SYSTEMS

7 to 20 Inch Diameter
Aluminum
or
Bronze
Slip Ring
Engraved Circles
Differential
Worm Assemblies
Complete Specifications
Furnished on Request
THOMAS MATHIS COMPANY
830 Williams St.
San Leandro, CA 94577
415-483-3090

MEADE EYEPIECES ARE WORTH A 2ND LOOK!

We would like to thank all of our customers for their support and enthusiasm. We will continue to provide you with the service and variety of product that is the policy of Northern Sky Telescopes. This month we have chosen to highlight the Meade Series 4000 Eyepieces with some specials that I think you will like. Don't forget we are still accepting entries for the drawing of the free Meade 2080 LX-5 until Sept. 30th, 1987. Good luck to everyone that has entered.

Jon Chase



Meade
2080 LX-5 w/MCOG **$1,739**
8" Schmidt-Cassegrain complete with field tripod and wedge. 9X60 RA polar illuminated viewfinder, AC/DC power supply or AA remote battery pack, quartz/pulse drive, 2" star diagonal, 2X or 8X scanning with remote. Don't forget to enter the drawing for this telescope! *(Special price!)*

Meade
2120 LX-5 w/MCOG **$2239**
10" Schmidt-Cassegrain with all features of the 8" but 56% brighter. *(Special price!)*

Meade Accessories

#712 Dew Shield	$ 59
#36 Remote Control	85
#38 or 38A Declination	85
#39 Declination	99
#419 Illuminated Reticle	85
#784 Quartz DC Motor Drive	165
#671 Wide-Field Adapter System	119
Off Axis Guider System Complete	149

VOGEL DIGITRAK
Drive Correctors

VE-200 Single Axis DC Power	$ 99
VE-300 Single Axis AC/DC Power	139
VE-300D Dual Axis AC/DC Power	189
VE-400D Dual Axis Internal Battery	219

MOTOFOCUS

Celestron C5/C8 Motorized Focuser	$89
Meade 2080/2120 Motorized Focuser	98
Bausch & Lomb 4000 Motorized Focuser	89

TELRAD
The "right spot" finderscope $39

We take pride in our service.
Free freight in U.S.
Most orders shipped within 24 hours.
30-Day Money-Back Guarantee.
Trade-ins and foreign orders welcome.
Call for estimate.
VISA and Mastercard accepted.

Meade DS-10A **$899**
10" f4.5 reflector with motor drive. Deep Space and Nebulas have never been closer.

Meade DS-16A **$1795**
16" f4.5 reflector with motor drive. The telescope that provides to your eyes what others must photograph.

Meade Series 4000
Eyepieces & Barlows!

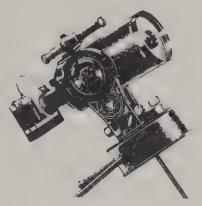
Super Plossl 6.4mm, 9.7mm, 12.4mm	$ 85
Super Plossl 15mm, 20mm, 26mm	85
Super Plossl 32mm or 40mm	105
Super Plossl 56mm	179
Super Wide Angle 13.8mm	135
Super Wide Angle 18mm	149
Super Wide Angle 24.5mm	159
Super Wide Angle 32mm	229
Super Wide Angle 40mm	295
Ultra Wide Angle 4.7mm	159
Ultra Wide Angle 6.7mm	189
Ultra Wide Angle 8.8mm	229
Ultra Wide Angle 14mm	259
#140 2x or #142 2.8x Barlow	79

With the purchase of any 2 Meade eyepieces or barlows you may choose either 1/2 off any Super Plossl 6.4mm thru 26mm or an eyepiece carrying case worth $30.00 free. Don't miss out on this exceptional special!

Meade 97E-II **$339**
3.5" Spotting Scope includes 45° erect-image prism and 5X21 erect-image viewfinder.

Meade 2045 **$539**
4" Schmidt-Cassegrain telescope includes 2 eyepieces, star diagonal, case, and more.

To order, or for pricing call toll free:
1-800-345-4202
For information:
1-612-545-6786
Call Jon Chase
Visit our Store:
Mon-Fri 9-6, Sat 10-2

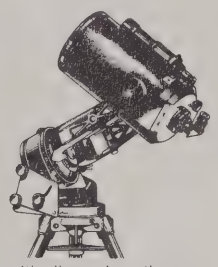


BAUSCH & LOMB 4000 Pro Kit **$439**
(Special price!)
4" Schmidt-Cassegrain with enhanced optical coatings providing 29% more light transmission. Includes 2x barlow and camera adapter. When you want the most for your money.

BAUSCH & LOMB 4000 **$389**
Same as 4000 Pro minus coatings, barlow and camera adapter. *(Special price!)*

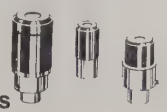
BAUSCH & LOMB Accessories

4000 Wedge & Tripod	$ 99
Solar Filter 4000	99
Polar Alignment Kit	29
Astrophotography Kit	69
10-17-26-35mm Pro Plossl Eyepiece	59



BAUSCH & LOMB 8001 Pro **$1089**
(Special price!)
8" Schmidt-Cassegrain with silvered coatings provides 20% more light transmission. Full field illumination, includes field tripod & wedge. It's worth looking into.

SWIFT 11 X 80 Binoculars **$219**
Includes tripod mount and case. "Tremendous brightness."



TeleVue Eyepieces

Plossl	
55mm	$155
40mm, 32mm	89
26mm, 21mm, 17mm, 13mm	75
10.5mm, 7.4mm or 1.8x, 2.5x Barlow	75
Wide Field	Call
Nagler	
20mm Type 2	$289
16mm Type 2	249
12mm Type 2	219
13mm	205
11m	195
9mm	185
7mm	159
4.8mm	129

TeleVue Oracle 3 **$699**
560mm 3" f7.4 triplet APO objective. Spotting scope, finder scope or lens. ***(Special price!)***

NORTHERN SKY TELESCOPES, INC.
5667 Duluth St.
Golden Valley, MN 55422
Specialists in Telescope, Binocular and accessory selection.

omcon

CRS RESEARCH GRADE REFLECTORS

OMCON 620 CRS 8" f/6 NEWTONIAN	$ 995.00
OMCON 525 CRS 10" f/5 NEWTONIAN	1195.00
OMCON 436 CRS 14" f/4.5 NEWTONIAN	1395.00
OMCON 1525 CRS 10" f/15 CASSEGRAIN	1595.00

ALL MODELS FEATURE:

- EQUATORIAL MOUNTING WITH 7" GEAR, 6" CIRCLES, 1.5" SHAFTS, SLOW MOTION POLAR AXIS, SLOW MOTION CONTROLS, WHEELS & LEVELLING
- DIFFRACTION LIMITED OPTICS, METAL TUBES WITH BALL BEARING ROTATION AND BALANCE BAR
- 2" ELECTRIC FOCUS WITH GUIDER OPTION & MORE!
- AVAILABLE: HAND PADDLE CONTROLLER WITH PHOTOGRAPHIC/SLEW FUNCTIONS $295.00

NEW! 50 PAGE CATALOG $3.00

OMCON PRODUCTS
1190 BALDY MTN LANE • BELGRADE MT 59714
SKY INSTRUMENTS
MPO BOX 3164 • VANCOUVER, B.C. V6B 3X6
CANADA Ph. (604) 270-2813

BERAL COATINGS

The ideal coating for front-surface precision mirrors.

Prices for Beral coating telescope mirrors: 3" to 5" — **$14.00**; 6" — **$18.00**; 8" — **$20.00**; 10" — **$25.00**; 12½" — **$30.00**. Prices for larger sizes on request. Diagonal 2" minor axis or smaller, when sent with mirror — **$5.00**. Add postage and insurance for return mail.

1927 60 YEARS OF SERVICE 1987

P. A. CLAUSING

8038 Monticello Ave. Skokie, Ill. 60076
Phone: (312) 267-3399

Tele Vue Dealers

Wilson Camera Sales
Phoenix, **AZ**
(602) 955-6773
California Telescope
Burbank, **CA**
(818) 505-8424
Bino
San Diego, **CA**
(619) 297-0797
Celestial Systems
Napa, **CA**
(707) 224-3195
Century Telescope Center
Garden Grove, **CA**
(714) 530-3861
Desert Sky Optical
Lancaster, **CA**
(805) 945-1171
L.A. Optical
N. Hollywood, **CA**
(818) 762-2206
Lee Mac Camera Exch.
Pasadena, **CA**
(818) 792-4343
Oceanside Photo
Oceanside, **CA**
(619) 722-3348
Lumicon
Livermore, **CA**
(415) 447-9570
Nelson Photo
San Diego, **CA**
(619) 234-6621
Optron Systems
San Jose, **CA**
(408) 923-6800
Orion
Santa Cruz, **CA**
(800) 447-1001
(800) 443-1001 in **CA**
Roseville Hardware
Roseville, **CA**
(916) 782-8402
Scope City
San Diego, **CA**
(619) 277-6686
Simi Valley, **CA**
(805) 522-6646
Torrance, **CA**
(213) 326-3251
Costa Mesa, **CA**
(714) 957-6900
Star Quest Enterprise
Orange, **CA**
(714) 633-8505
Martins Star Tracker
Boulder, **CO**
(303) 449-3350
Colortone
Stamford, **CT**
(203) 357-1413
New England Astro-Optics
Simsbury, **CT**
(203) 658-0701
Colonial Photo & Hobby
Orlando, **FL**
(305) 841-1485
Sunwest Space Systems
St. Petersburg, **FL**
(813) 577-0629
Scientific Wizardry
Boise, **ID**
(208) 377-8575
Cosmic Connections
Aurora, **IL**
(312) 851-5353
F.C. Meichsner Co.
Boston, **MA**
(617) 426-7092
Frank Krauth, Co.
South Weymouth, **MA**
(617) 331-3795
Company Seven Astro-Optics
Laurel, **MD**
(301) 953-2000
University Optics, Inc.
Ann Arbor, **MI**
(313) 665-3575
National Camera Exchange
Minneapolis, **MN**
(612) 546-6831
Northern Sky Telescopes, Inc.
Golden Valley, **MN**
(800) 345-4202
Bergen County Camera
Westwood, **NJ**
(201) 664-4113
Camera Discount Center
Paramus, **NJ**
(800) 631-7111
Dover Photo Supply
Dover, **NJ**
(201) 366-0994
The Photo Center
Bricktown, **NJ**
(201) 840-1333
Roger W. Tuthill
Mountainside, **NJ**
(201) 232-1786
Edelman's
Wayne, **NJ**
(201) 256-2071
Adorama
New York City, **NY**
(212) 741-0052
Advance Camera
New York City, **NY**
(212) 944-1410
Berger Bros. Camera Exch.
Amityville, **NY**
(516) 264-4160
Camera Concepts
Patchogue, **NY**
(516) 475-1118
Riverhead, **NY**
(516) 727-3283
The Camera Co.
Greenvale, **NY**
(516) 621-0606
Clairmont-Nichols
New York City, **NY**
(212) 758-2346
Colortone
White Plains, **NY**
(914) 949-7884
Edwin Hirsch
Tomkins Cove, **NY**
(914) 786-3738
Ken Mar Camera
Great Neck, **NY**
(516) 482-1025
Nautical Service
Northport, **NY**
(516) 757-7169
TBR Optisystems
Rochester, **NY**
(716) 544-2162
Optics Ohio
Lancaster, **OH**
(312) 851-5353
Ad-Libs Astronomics
Norman, **OK**
(800) 422-7876
Scope Source
Ardmore, **OK**
(406) 226-3068
Mid City Camera
Philadelphia, **PA**
(215) 735-2510
American Camera Ctr.
Memphis, **TN**
(901) 683-2200
Cooter's Village Camera
Dallas, **TX**
(214) 392-2755
Texas Nautical Repair
Houston, **TX**
(713) 529-3551
Bill Weaver Sporting
Ft. Worth, **TX**
(817) 731-0804
Z Optical Shop
Stafford, **TX**
(713) 499-3000
Aries Optics
Palouse, **WA**
(509) 878-1713
Optical Illusions, Inc.
Bellevue, **WA**
(206) 454-1101
Manitoba Museum
Winnipeg, Manitoba, **Canada**
(204) 956-2380
Perceptor
Toronto, Ont., **Canada**
(416) 694-8273
Scope City
Toronto, Ont., **Canada**
(416) 783-4140
Quasar Optics
Calgary, Alberta **Canada**
(403) 255-7633

"The ★ stars never set on Observa-DOME"

This five-meter Observa-Dome, located in the Kingdom of Saudi Arabia, is one of four currently being used in a site selection survey by the Saudi Arabian National Center for Science and Technology.

From the ends of the earth to the beginning of infinity.

Observa-Dome is there.

As the country's oldest dome manufacturer, Observa-Dome has developed an expertise unmatched in the industry. Our clients are world-wide, from the United States Government to the amateur astronomer. Defense, tracking, research, communications. No matter what the use, the climate, the installation, the design, Observa-Dome meets the challenge.

For further information call or write:

Observa-DOME

LABORATORIES, INC.
371 Commerce Park Drive/Jackson, MS 39213
Phone (601) 982-3333
Toll Free—800-647-5364 Telex 585438

Star-Liner Co.®
1106 S. Columbus
Phone No. (602) 795-3361
Tucson, Arizona 85711

Catalogue: $5 U. S., $8 overseas

THERE IS A DIFFERENCE—PROVEN DESIGN AND 30 YEARS EXPERIENCE

Our Company has designed some of the finest quality telescopes; other companies have come and gone but proven design and personal care to our many hundreds of customers throughout the world have given us a reputation to be proud of.

We can handle your request for any size telescope from our 6" amateur unit to our well known Observatory Research Models installed in many Universities and Research Companies in the United States as well as foreign countries. Our price range is sometimes lower than other companies and we offer **REAL QUALITY UNITS WITH STABILITY AND BEAUTY IN MIND.**

YOKE DESIGN MOUNTING **GERMAN MOUNTINGS**

Dual, Cass., f/11, Newt. f/4, 14¼" and 10" shown

10" f/6 Newt. with guide scope, 50mm finder scope

12.5" f/5, quality line yoke, transportable

Research observatory 20" model Cass. f/12

Jupiter

M-57

M-42

Moon

Sun

Comet Kohoutek

All these astrophotographs were taken through our fine quality **STAR-LINER** Telescopes ranging in optical size from 6" to 20". Our fine line of telescopes comes in various modes 6" to 24". Write for our list of fine quality telescopes located in many parts of the United States and foreign countries. You'll be pleased with our quality and our service

Many telescopes in stock ready for delivery.

"Use The Best: Tele Vue. After All, The Eyepiece Is Half Your Telescope"

— Dr. Jack Marling

Patented Tele Vue eyepiece designs started a revolution. Bringing you far more field, sharpness and contrast than ever before. And still today, genuine Tele Vue Plössl, Wide Field, and Nagler eyepieces deliver greater apparent field and edge sharpness than any imitative models. When you make a lifetime investment in quality eyepieces, there's only one choice. Tele Vue.

For complete information, including a detailed guide to selecting eyepieces for your telescope, send $1 today.

Tele Vue™

20 Dexter Plaza, Pearl River, NY 10965
Telephone: (914) 735-4044

OBSERVATORY SERIES - This superbly designed Newtonian features a massive 2½" solid steel threaded shaft. Mount is capable of handling up to 20" telescopes. Precision roller bearings in both axes. Complete with electric right ascension and declination drives w/controls, rotating rings, two 1¼" multi-coated Plossls, giant 8x50 right angle/straight through finderscope, 2" focuser with 1¼" adapter, genuine Parks fiberglass tube with matching aluminum end rings and dust covers. It is the very best available.

Complete 16" Observatory $12,000
Complete 14¼" Observatory ..... $ 8,900
Complete 12½" Observatory ..... $ 7,500
(Shown above)
2½" Mount only $6,500
4" Shaft Mount ..... $25,000 & up
INFO. AVAILABLE UPON REQUEST

SUPERIOR NEWTONIAN SERIES - The Superior series features a 1½" solid steel, threaded shaft mounting with electric right ascension and declination drives, slo-motion controls, rotating rings, two - 1¼" multi-coated Plossl oculars, giant 8x50 right angle/straight through finderscope, 2" focuser with 1¼" adapter, genuine Parks fiberglass tube with matching aluminum end rings and dust covers. Quality components throughout.

12½" f/5 Superior Complete $3,299
10" f/5 Superior Complete $2,299
1½" Mount Only Complete $1,699

SUPERIOR NEWTONIAN SERIES - The Superior series features a 1½" solid steel, threaded shaft mounting with electric right ascension and declination drives, slo-motion controls, rotating rings, two - 1¼" multi-coated Plossl oculars, giant 8x50 right angle/straight through finderscope, 2" focuser with 1¼" adapter, genuine Parks fiberglass tube with matching aluminum end rings and dust covers. Quality components throughout.

8" f/5 Superior Complete $1,999

6" PRECISION NEWTONIAN - Enter the spectacular world of Newtonians with the economical and quality Precision series. Base unit starts you with a 1" shaft equatorial mount w/declination, slo-motion control and your choice of a 6" f/6, 6" f/8 or an 8" f/6 optical tube assembly. Electric clock drive and declination slo-motion controls (optional). 6" f/6, f/8 and 8" f/6 includes: 1¼" focuser, 6x30 finderscope, 25mm 1¼" ocular, genuine Parks fiberglass tube w/matching aluminum end rings, and dust covers.

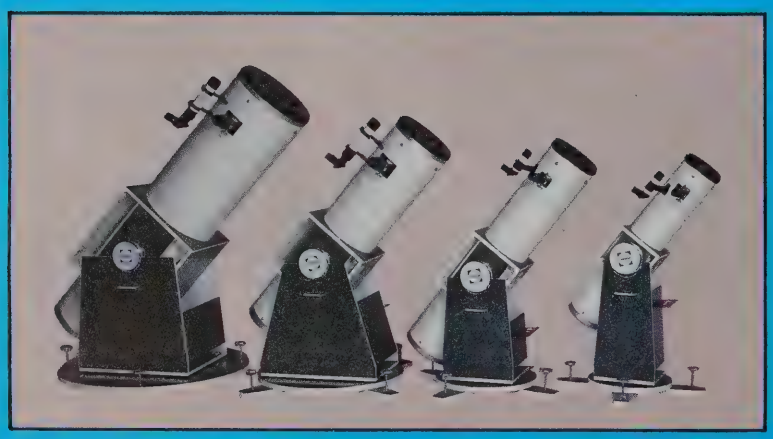
6" f/8, f/8 complete ..... $799 1" Shaft Mount $399
8" f/6 complete ..... $999 Elec. Clock Drive w/Slo-Motion Control ... $299

PRT-1 REFRACTOR
Study the cloud bands on Jupiter as well as the majestic rings of Saturn with this 60mm refractor telescope. Utilizes metal tube and quality components throughout. Fully coated 60mm achromatic objective lens provides sharp, crisp images. 700mm focal length. Comes complete with 12.5mm and 6mm .96" ocular, star diagonal, 5x24 finderscope, sturdy alt-azimuth mounting, and adjustable wooden tripod. **$149**

PRT-2 REFRACTOR
Whether for terrestrial or astronomical use, the PRT-2 will give you hours of viewing pleasure. 60mm fully coated achromatic objective lens with 700mm focal length. Extra sturdy metal alt-azimuth mounting has fine slow motion controls in both axes for precise centering and tracking of objects of interest. Complete with 6mm (117x) and 20mm (35x) ocular, star diagonal, 2X barlow, accessory tray, built-in 10X finder, and adjustable wooden tripod.

$195

PRT-46 REFRACTOR
May be the best 60mm refracting telescope available in its class. Brilliant images. 910mm focal length, 60mm fully coated achromatic objective lens. Equatorial mount with right ascension and declination slow-motion controls. Complete with 4mm, 9mm, and 22mm oculars, star diagonal, erecting prism, solar projection screen, 2X barlow, built-in 10X finder, moon filter, heavy duty adjustable wooden tripod and illuminated accessory tray. **$349**



TRAVEL THE UNIVERSE FIRST CLASS . . . AT AN ECONOMY FARE!

Introducing the all new

PARKS DOBSONIAN REFLECTORS!!

Designed and engineered to be the very best performing alt-azimuth Newtonian telescope on the market today. Available in 6", 8", 10" and 12½" sizes: each unit utilizes Parks fiberglass tubes, fine annealed, full thickness pyrex optics and quality components throughout. The mountings are manufactured from thick industrial grade particle board and are covered with a durable marble design laminate. All edges are finished with a decorative PVC banding. Base and leg supports are edged with a protective vinyl bumper. Mount is designed to dampen vibration quickly and efficiently. Tube mount is hinged to allow easy mounting and rotation of the tube. All telescopes and mounts include: wheels, leveling screws, accessory tray and carrying handles.

6" f/6, f/8 and 8" f/6 includes: 25mm 1¼" ocular, 6x30 right angle finderscope, 1¼" focuser and dust covers.

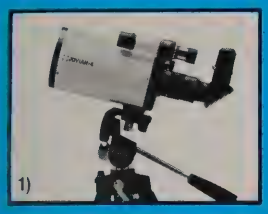
10" and 12½" f/5 includes: 25mm 1¼" ocular, giant 8x50 right angle/straight through finderscope, 2" focuser with 1¼" adapter and dust covers.

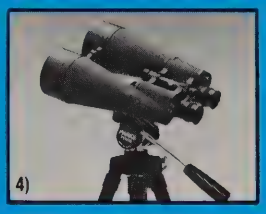
COMPLETE UNITS:

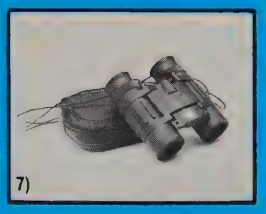
6" f/6, f/8 ..... $499
8" f/6 ..... $649
10" f/5 ..... $999
12½" f/5 ..... $1,299

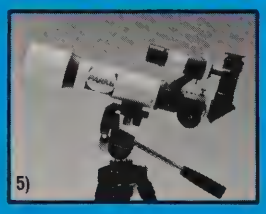
MOUNTS ONLY

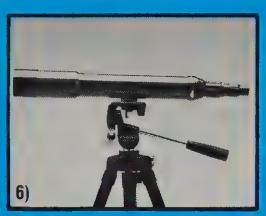
6" $219
8" $249
10" $299
12½" $349











1). **JOVIAN-4.** Enjoy the compactness, portability and quality of this 4-inch Schmidt-Cassegrain. Superior optics provide bright color corrected images that are crisp to the edge of the field. Complete with unique built in camera adapter, 5x24 finder, 25mm 1¼" Plossl, lens cover, carrying case w/shoulder strap, and 1¼" diagonal prism. **$399**

2). **EYEPIECES.** Parks offers a complete line of Kellner, Orthoscopic, Plossl, and Erfle oculars. All professional high quality optics in precision machined brass and aluminum housings. Threaded barrels accept all popular filters. Multi-coated for excellent light transmission and image contrast. See below for pricing.

3). **COLOR FILTERS.** Increase contrast and resolution of lunar and planetary detail with 1¼" photo visual color filters. Made of the finest quality Hoya glass with 26mm of clear aperture. Threaded on both ends to allow stacking. **Each $10**
Polarizer $15

4). **GIANT BINOCULARS.** Quality giant 80mm objective lens. Advanced ZCF design with central support bridge. Fully coated for maximum image contrast. Includes lens shades, straps, deluxe carrying case and photo-tripod adaptor. **$179**

5). **WIDE FIELD 60.** Maximum resolution and long eye relief. 60mm fully coated air spaced objective lens. 420mm focal length with 28mm 1¼" ocular provides ultra wide 3 degree field of view. Includes star diagonal and 6 x 30 finder. Mounts on any standard photo-tripod. **$179**

6). **ZOOMSCOPE 60.** 60mm coated objective lens. Metal construction zooms from 15X to 60X power. Mounts easily on any standard photo-tripod. Excellent terrestrial telescope. **$99**

7). **COMPACT BINOCULARS.** Widest field available. Light weight, multi-coated roof prism. Black rubber for shock resistance. Complete w/straps and case.
8 x 25, 8.7° $59
10 x 25, 7° $67

8). **SUPER SPOTTER.** Versatility at its best! 60mm fully coated objective lens. Rotatable head allows you to select 20X or 50X magnification. Utilizes 4 element Orthoscopic eyepieces. Straight through or right angle viewing. Great for astronomy, nature hikes, whale watching, firing ranges, and much more. **$169**

9). **COMPANION.** Compact and lightweight. 9X to 30X zoom spotting scope. 40mm coated objective lens. Mini table top tripod included. **$49**

Kellner Oculars

6, 12, 25 or 40mm 1¼" $25.00
50 or 60mm 2" $49.00

Orthoscopic Oculars

6, 12.5 or 25mm 1¼" ... 39.00

Plossl Oculars

6, 9, 12.5, 18, 25 or
40mm 1¼" 49.00
50mm 2" 69.00

Erfle Oculars

20 or 32mm 1¼" 49.00
32mm 2" 79.00

Barlow Lenses

2x Barlow Lenses 1¼" . 29.00
2x Barlow Lenses 2" ... 69.00

Visual Accessories

Star Diagonal 1¼" 39.00
Hybrid Star Diagonal ... 29.00
Porro Prism 96" 39.00
Porro Prism 1¼" 49.00

Camera Adapters

Camera Adapter 96" ... 29.00
Camera Adapter 1¼" . 29.00
Camera Adapter 2" 29.00
Super Spotter 19.00
Parks Wide-Field 60 .... 19.00

T-Rings

Pentax 'S', Pentax 'K' Nikon, Minolta, Canon, or Olympus T-Ring . 9.00

Guidescopes

60mm x 700mm f/l Refractor Guidescope 129.00
60mm Mounting Brackets per pair 20.00

Finderscopes

6x30 7° field 33.00
Rt. angle, 7° field 37.00
6x30 Finderbracket 8.00
Deluxe 8x50 ..... 139.00
(Can be used straight through or rt. angle, removable 1¼" ocular 4¼ degree field)
8x50" Mounting Brackets ..... 15.00 pr.

Elliptical Secondary Mirrors

1.33" Elliptical Mirror ... 25.00
1.55" Elliptical Mirror ... 29.00
1.83" Elliptical Mirror ... 35.00
2.14" Elliptical Mirror ... 41.00
2.60" Elliptical Mirror ... 50.00
3.10" Elliptical Mirror ... 75.00

Focusers

1¼" Focuser 39.00
2" Focuser
(w/1¼" adapter) 59.00

Primary Mirror Cells

6" Mirror Cell 29.00
8" Mirror Cell 39.00
10" Mirror Cell 49.00
12½" Mirror Cell 69.00

Spider/Diagonal Holders

Spider 7" I.D. Tube 14.00
Spider 9⅜" I.D. Tube ... 15.00
Spider 11⅞" I.D. Tube .. 16.00
15⅞" I.D. Tube 19.00

1.33" Diagonal Holder .. 12.00
1.55" Diagonal Holder .. 13.00
1.83" Diagonal Holder .. 14.00
2.14" Diagonal Holder .. 16.00
2.60" Diagonal Holder .. 20.00
3.10" Diagonal Holder .. 25.00

Setting Circles

6" Engraved Alum. Setting Circles 1" Bore 39.00
6" Engraved Alum. Setting Circles 1½" Bore 39.00

Mounting Rings

Clamp Rings for 7" Tube 50.00
Clamp Rings for 9⅜" Tube 60.00
Clamp Rings for 11⅞" Tube 70.00
Rotating Rings for 9⅜" Tube 195.00
Rotating Rings for 11⅞" Tube 295.00
Rotating Rings for 15⅞" Tube 395.00
Rotating Rings for 18" Tube 495.00

Light Pollution Blocking Filter

LPB Filter 1¼" 59.00
LPB Filter 2" 69.00

Photo Visual Color Filters

1A, 8, 11, 12, 15, 21, 23A, 25, 29, 38A, 47 56, 58A, 80A, 82A, ND13 ND25, ND50. ..... 10.00
Polarizing Filter 15.00

Fiberglass Tubes & End Rings

For 4½" Mirror
5" x 48" 39.00
For 6" Mirror
7" I.D. x 31" to 52" 52.00
7" I.D. x 53" to 60" 56.00
Alum End Rings per pair 20.00
For 8" Mirror
9⅜" I.D.x24" to 37" ... 56.00
9⅜" I.D.x38" to 55" ... 68.00
9⅜" I.D.x56" to 60" ... 72.00
9⅜" I.D. x 61" to 75" .. 80.00
Alum. End Rings
per pair 25.00
For 10" Mirror
11⅞" I.D.x40" to 48" ... 99.00
11⅞" I.D.x49" to 62" .. 116.00
11⅞" I.D.x63" to 72" .. 132.00
Alum. End Rings
per pair 34.00
For 12½" or 14¼" Mirror
15⅞" I.D.x48" to 59" .. 148.00
15⅞" I.D.x60" to 69" .. 160.00
15⅞" I.D.x70" to 79" .. 170.00
15⅞" I.D.x80" to 100" . 190.00
Alum. End Rings
per pair 40.00
For 16" Mirror
18" I.D.x48" to 60" 160.00
18" I.D.x61" to 90" ... 240.00
18" I.D.x91" to 120" .. 280.00

Parabolic Primary Mirrors

6" f/6, f/8 Mirror 99.00
8" f/6 Mirror 159.00
10" f/5 Mirror 299.00
12½" f/5 Mirror 499.00

Photographic Tripods

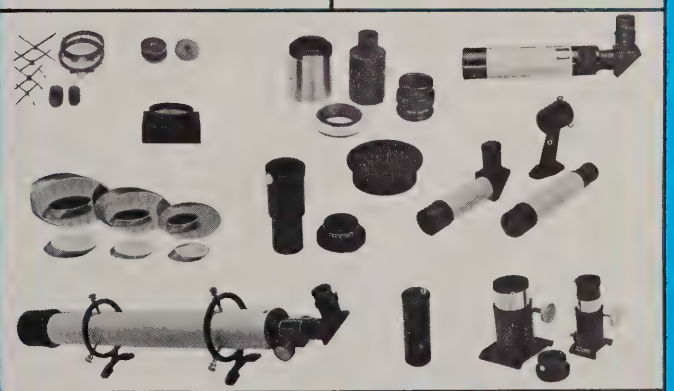
Tripod (spring loaded) .. 99.00
Deluxe Tripod (fluid head) 175.00
Table Top w/Micro Adj. .. 49.00
Mini Table Top Tripod ... 19.00
Slow-Motion Control to fit Photo-Tripod 39.00

7x35 WIDE FIELD. Whether at a sporting event or gazing at the Milky Way, the Parks 7x35 ultra wide-field binoculars will provide excellent viewing with an incredible 12½° field. Fully coated, heavy-duty construction, yet compact. Complete with lens cap, straps and case. $69

ILLUMINATED RETICLE. New state-of-the-art cordless design featuring rheostatic brightness control and on/off switch. Top quality 1¼ 12.5mm multi-coated Orthoscopic w/fully focusable dual crosshair for precision guiding. $79

OBSERVING CHAIR. View in comfort. Sturdy, yet light weight. Fully adjustable height. Thick padded upholstered seat. Chrome-plated tripod legs fold up for extreme compactness and portability. $47

TELESCOPE DUST COVERS. Now available for 6", 8", 10" and 12½" 14" telescopes. Manufactured from durable ABS Plastic. Each cover is felt lined for a tight fit. Additional felt is included for fitting of various tube sizes.
For 6" telescope $10 ea. For 10" telescope $15 ea.
For 8" telescope $12 ea. For 12½" 14" telescope $20 ea.



PARKS OPTICAL
270 Easy St.
Simi Valley, California 93065
Information ..... (805) 522-6722
Order only in CA. 1-800-43-PARKS
Order only National 1-800-44-PARKS

All Parks products come with 100% satisfaction guarantee or return in original condition for a full refund, less shipping within 30 days of receipt. 10" or larger telescopes, mountings, and tubes over 9⅜" are shipped freight collect. All other merchandise add 3% in continental USA to cover shipping and handling. (Minimum $4). Air freight and shipping worldwide, information upon request. FREE COLOR CATALOG. (foreign USD $5). Parks Optical is not open to the public. Merchandise available through mail order or at any authorized Parks dealer worldwide. Most of listed products in this ad are offered at very special prices. Suggested retail price is higher.

Create Your Own Universe In Just 10 Minutes.

When **STARLAB** was introduced in 1977, it was designed as a portable **planetarium.** Today the variety of its applications is becoming as limitless as the universe itself. **STARLAB'S versatility** makes it an exciting tool for educators in astronomy, geography, biology, social studies and art. It has even served as a photo darkroom and a movie theatre.

STARLAB'S portability enables it to travel to the students. This unique planetarium is **lightweight, easy to operate,** and takes only **10 minutes** to set up. Made in the USA, **STARLAB** is backed by a **customer support system** which includes suggested curriculums, direct access to our production staff and much more.

Millions of students around the world have already been introduced to astronomy through the use of **STARLAB**. For further information, send for our detailed brochure. We can even arrange a free demonstration anywhere in the country. After all, **STARLAB** ***is*** portable.

Learning Technologies Inc.
59 Walden Street, Cambridge, MA 02140
(617) 547-7724 Telex: 5106008300 LRNG TEC

PUZZLED WHEN CHOOSING OPTICAL EQUIPMENT?

Let the trained professionals at Scope City help you make the choice that's best for you.

Scope City

VISIT THE WORLD'S LARGEST AND MOST COMPLETE TELESCOPE & BINOCULAR DISCOUNT CENTERS. NOW FOUR LOCATIONS TO SERVE YOU!

MAIL ORDER
Call for the most competitive prices
P.O. Box 440
Simi Valley, CA 93065
Information: (805) 522-6701

MAIN OFFICE
679 Easy St.
Simi Valley, CA 93065
(805) 522-6646

Showroom:
SAN DIEGO, CA
4766 Clairemont Mesa Blvd.
(805 Fwy. to Clairemont Mesa Blvd. exit, West.)
(619) 277-6686

Showroom:
COSTA MESA, CA
3033 S. Bristol
(405 Fwy. to Bristol exit, 2 blks South)
(714) 957-6900

Showroom:
TORRANCE, CA
3132 Pacific Coast Hwy
(405 Fwy. to Crenshaw exit South, West of Pac. Coast Hwy 3 blks)
(213) 326-3251

Showroom:
SIMI VALLEY
679 Easy St.
(118 Fwy to First St. exit, South ½ mile, right on Easy St., 2 blks)
(805) 522-6646

C.O.D. & CHARGE CARDS

TO ORDER, CALL TOLL FREE

800-521-2828

IF BUSY, CALL (313) 665-3575

MONDAY THRU SATURDAY

9:30 a.m. to 9:30 p.m. E.S.T.

FREE CATALOGUE (via 3rd Class) — **For First Class Delivery Remit $1.00 Air Mail Outside North America $3.00**

HOW TO ORDER

MAIL ORDER: No special order forms required. Simply write a letter with your requirements. Payment via VISA, MASTERCARD, personal check or money order. Do not send cash. No minimum order.

FOREIGN ORDERS: We now specialize in fast service to any place in the world. Requests for pro forma invoices welcome. We will tell you exact postal charges and other particulars.

Tele Vue

We carry the full line of Tele Vue telescopes, eyepieces, & accessories.

When you have decided to make the move up to **Tele Vue** equipment, give us a call for advice on the best eyepiece or telescope to fit your exact needs. We especially recommend the Nagler eyepieces as having outstanding optical characteristics. Please call **Toll Free** for details.

Königs by University

The remarkable wide-angle König leads the field in high-performance!

König Eyepieces — With their wide angle and pinpoint definition, these truly are the "king" of wide field eyepieces. The perfect match for all those large Dobsonians now available. All are multi-coated and threaded for our special wide-aperture photo-visual filters. 1¼" O.D.

6.5mm, 8mm, 12mm, 16mm, and 24mm. Each eyepiece for only ..... **$59.95 ppd.**
32mm ..... **$74.95 ppd.**

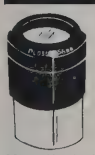
Astro Film

University Optics has been licensed to perform the gas hypersensitization of photographic film using the procedures defined under U.S. Patent 3,984,249. Our 25 years experience in astronomy and professional photography assures you a quality product. Films listed are 35mm unless noted.

Film Type	Exposure	Price
2415, ultra-fine grain B&W	36	$10.95 ppd.
3M 1000 (sensitized)	16	$12.95 ppd.
Fujichrome 400	20	$12.95 ppd.
Sakura 1600, color negative	24	$11.95 ppd.
3M 1000 (unsensitized)	20	$7.50 ppd.

All film comes packed with dust-free packages of a drying agent. **2 or more rolls, 10% discount**

2″ O.D. Eyepieces



We carry some of the finest quality giant 2" O.D. oculars in the country. Black aluminum cells with chrome plated brass barrels. All are threaded for 48mm filters. Try our 55mm Plössl in combination with our 2" O.D. star diagonal for true wide angle views of the heavens.

32mm Konig-2. ..... Multi-coated, wide field design ..... **$99.95 ppd.**
40mm Konig-2. Multi-coated ..... **$99.95 ppd.**
40mm Konig 7/70°.—A new Konig with 7 elements and a 70° field ..... **$215.00 ppd.**
55mm Plössl. Multi-coated ..... **$99.95 ppd.**

Amici Diagonals

Tired of reversed and confused images when looking through your telescope? Give our quality Amici prisms a try!

Amici 1¼" O.D. ..... **$59.95 ppd.**
Amici 0.96" O.D. ..... **$59.95 ppd.**

Zoom Orthoscopic

Zoom Orthoscopic — This is the same fine quality continuous variable zoom we have sold for many years. Coated lenses with precision 7-element optical system. Takes the place of several individual eyepieces. 8.4 to 21mm focal length. **$85.95 ppd.**

Accessories for Celestron

Camera quality visual and photographic accessories for your Celestron and Meade Series 1000 and 2000 telescopes.

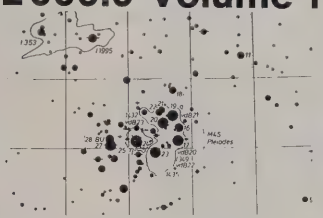
T-Adapter ..... **$28.95 ppd.**
Tele-Extender ... **$29.95 ppd.**
Telecompressor (f/5) Includes extender tube for use with off-axis guider ..... **$69.95 ppd.**
Piggyback camera adapter for C-8 ..... **$32.95 ppd.**
Deep-sky f/5 visual adapter — Includes telecompressor lens, special T-Adapter, threaded ring, and wide aperture diagonal prism. .... **$95.95 ppd.**
Off axis guider body with 12.5mm orthoscopic illuminated reticle eyepiece ..... **$139.95 ppd.**
Off-axis guider body only ..... **$68.95 ppd.**

Illuminated

A new high-tech 8×50 viewfinder from University Optics! Fully illuminated with a precision Polaris alignment scale to help you get perfect alignment everytime under any conditions. Crosshairs in center of field as well as unique Polaris scale are illuminated with self-contained LED. No external wires. Large 1¼" size diagonal and eyepiece mechanism assures wide field of view. An advanced mounting bracket with 6 special screws will not mar the fine finish. Available in black for Celestron 8 and other telescopes and dark blue for Meade telescope line ..... **$119.95 ppd.**

Uranometria

2000.0 Volume 1



Tirion, Rappaport, Lovi ..... **$39.95 ppd.**

Extended Hours!
9:30 a.m. to 9:30 p.m. E.S.T.
TOLL FREE ORDER LINE
1-800-521-2828

Binocular Viewer

Our binocular viewer is still the quality leader! Fits any 1¼" telescope. Uses two of your 1¼" eyepieces. Removable Barlow. 45° viewing angle ..... **$389.95 ppd.**

11×80 Amici

It's a fantastic viewfinder! It's a versatile rich-field telescope! It's a compact spotting scope for nature study! We started with an 80 mm fully coated achromatic objective. We added a **fine quality 1¼" rack and pinion, 30 mm 1¼" crosshair eyepiece, and a 1¼" Amici diagonal prism for correctly oriented images!** Complete with tripod mounting block. Beautiful midnight black finish. Perfect for comet hunting. ..... **$239.95 ppd.**
With normal diagonal ..... **$199.95 ppd.**
KIT of all parts without diagonal or eyepiece ..... **$135.00 ppd.**

Special Filters

MARK-5 Visual — An extremely high contrast filter for visual use only. For areas of extreme light pollution. Gives remarkable results on planetary and emission nebulae. Very narrow bandpass. For all 1¼" eyepieces. Premium grade ..... **$59.95 ppd.**

MARK-5 Photo Visual — This is the choice for photo and visual use on most deep-sky objects. The broad band makes it ideal for astrophotography. For all 1¼" eyepieces. Premium grade ..... **$59.95 ppd.**

Variable Density Polarizer — For 1¼" eyepieces. Reduces the glare on bright objects. Our unit has two glass filters in a rotating cell. (range is about 5% to 30% blockage) ..... **$32.95 ppd.**

1¼" Color Filters — We have red, green, yellow, orange, blue, and medium neutral density ..... **$12.95 ea. ppd.**

Wireless

A Major Advancement in Illuminated Eyepieces!

No more tangled wires! This 12.5mm 1¼" O.D. illuminated orthoscopic eyepiece has every important feature built right in. Focusable etched glass double crosshair. With its LED illumination, brightness control, and on-off switch right at your fingertips, this is an absolute must for serious astrophotographers. Threaded for filters ..... **$82.95 ppd.**

Books Books

Astronomical Formulae For Calculators. Revised Edition. By Jean Meeus ..... **$14.95ppd.**

Astronomical Tables of the Sun, Moon, and Planets. By Jean Meeus ..... **$20.95ppd.**

Microcomputer Control of Telescopes. By Trueblood & Genet ..... **$19.95ppd.**

How To Make A Telescope. Revised and enlarged Second Edition. By Texereau ..... **$19.95ppd.**

Camera Adapter

Professional Camera Adapter — Couples your camera to any 1¼" O.D. focuser. Excellent quality anodized aluminum. For first focus and eyepiece projection. Threaded for 27mm photographic filters. Standard T-thread. Use with camera T-ring listed below ..... **$28.95 ppd.**

For Imported Scopes—Same high quality as above unit only fits .96" O.D. telescopes .... **$29.95 ppd.**

T- Camera Rings

Camera T-Rings - Pentax K, Pentax S, Yashica, Canon, Minolta, Exakta, Konika, Olympus OM-1, OM-2 ..... **$12.95 ppd.**
T to C mount — Attaches TV cameras with "C" mounts to standard T-adapters .... **$20.95ppd.**

New Items

3 Power Barlow — This unusual Barlow has three elements, each element being air-spaced from the other elements in the system. 1¼" O.D. ..... **$75.00 ppd.**

80mm 2" O.D. Plössl — The perfect low power eyepiece for those long focal length scopes . . **$195.00 ppd.**

65mm 2" O.D. Plössl . This superb 5-element eyepiece yields wide views of the heavens ..... **$195.00 ppd.**

Rack & Pinion for Schmidt-Cass. — Convert your Meade or Celestron to smooth, trouble-free helical rack & pinion focusing.
1¼" O.D. Model ..... **$49.95 ppd.**
2" O.D. Model ..... **$79.95 ppd.**

6.5mm König — A new short focal length version of our popular 1¼" O.D. König line of wide angle eyepieces . . .. **$59.95 ppd.**

Foucault Tester Kit — A greatly improved version of the mirror tester we sold through the years.
Kit of all parts ..... **$39.95 ppd.**
Completely assembled ..... **$99.95 ppd.**

Deep-Sky Binoculars

These are the same excellent quality 80mm giant binoculars that we have sold for years. Available in 11 power or 20 power and come complete with tripod adapter, collimation certificate, and case. **New multi-coated models available.** Please call **Toll Free** for latest price.

Astrophotography

Astrophotography, Second Edition Revised and Enlarged

by Barry Gordon. If you purchase only one book on astrophotography, make sure this is it!

All photography in this revised and enlarged edition were taken by amateurs using standard, commercially available equipment. Shows you how to get good results right from the start. Determining correct astronomical exposures is simplified using Gordon's "fx system" **$18.95 ppd.**

Astrophotography-II—Featuring the Techniques of the European Amateur. Patrick Martinez ..... **$18.95 ppd.**

8×50 Viewfinders

This all new University 8x50 viewfinder uses standard 1¼" eyepieces. The cell, tube, and eyepiece holder are metal for years of service. Don't confuse this unit with those made mostly of plastic! Comes with 1¼" star diagonal, and 1¼" wide-field Kellner with crosshair. Fully-coated achromatic 50mm objective lens. Mounting bracket is extra. Choice of black or white finish.

Fits Celestron 8, Meade 2080, Odyssey, and most reflectors ..... **$85.95 ppd.**

Sturdy Mounting Bracket (six adjustment screws) ..... **$16.95 ppd.**

Straight-Through Adapter. Converts the above to straight through viewing ..... **$10.95 ppd.**

2″ Star Diagonal

At last, an economical way to convert your telescope to 2" O.D. eyepieces!

Use with our 55mm Plossl. By using a clever design that allows you to screw our diagonal onto your **Meade, Celestron,** or **Dynamax** T-adapter, we saved weight and cut machining costs drastically ..... **$89.95 ppd.**

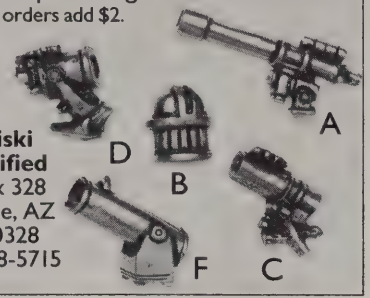
2" to 1¼" adapter ..... **$15.95 ppd.**

UNIVERSITY OPTICS
P. O. Box 1205
Ann Arbor, Michigan 48106

Money-back guarantee on all items. We are now completing our second decade of service to astronomers.

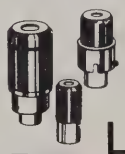
Three-dimensional pins in pewter or silver

pewter $7.50 each; silver $17.50 each.
Write for prices in gold.
Foreign orders add $2.



Kowaliski Diversified
PO Box 328
Glendale, AZ
85311-0328
602-978-5715

CANADA



Tele Vue
WIDE FIELD NAGLER PLOSSL

LOW PRICES
We Ship Across Canada
Catalogue $3.00

SCOPE CITY CANADA
247 MARLEE AVENUE, UNIT 201
TORONTO, ONTARIO, CANADA
M6B 4B8 tel: (416) 783-4140

Not associated with Scope City of California

WE BEAT THE LOWEST PRICES!!
ON ALL OUR TELESCOPES AND ACCESSORIES! Call (714) 530-3861

MEADE • CELESTRON • TELEVUE

2120LX5 . . . . . 1895.00
W/MCOG
2120LX3 . . . . . 1795.00
W/HAND CONTROL BOX

OUR PACKAGE DEAL:
2120LX5 W/MCOG (complete factory pkg.), Dec. Motor, Dew Shield, Weight System, 2XBarlow, 9mm 1¼" Eyepiece, T-adapter, T-mount, Telextender, Acc. Case.
ONLY 2299.

Series 4000 Below Dealer Cost

SUPER PLOSSL
6.4, 9.7, 12.4, 15, 20, 26mm 69
32, 40mm 89
56mm 159

SUPER WIDE ANGLE
13.8mm 109
18mm 119
24.5mm 129
32mm 189
40mm 249

ULTRA WIDE ANGLE
4.7mm 129
6.7mm 159
8.8mm 189
14mm 219
Barlow 2X, 2.8X . 69

Same Low Prices for TELEVUE eyepieces

Monthly Telescope Classes

MEADE CD'S BEST BARGAIN:
#2045 499
#6600 419
#8800 599
#2045LX3 599
#300 349
#320 399

NEW!
MTS-SN6 499
MTS-SC8 749
MTS-SN8 749
MTS-SC10 1199

(Call for Details and Other Prices)

MEADE • CELESTRON • TELEVUE

CENTURY TELESCOPE CENTER 12555 HARBOR BLVD. GARDEN GROVE, CA 92640

Brochures and specifications available.
ASH MANUFACTURING COMPANY, INC.
BOX 312, PLAINFIELD, ILLINOIS 60544 AC-815 436-9403

ASH DOME

FOCUS ON

Rothney Astrophysical Observatory University of Calgary Calgary, Alberta, Canada

The Rothney Astrophysical Observatory has recently expanded its facility with a new building to house a 1.83-m infrared telescope and a 0.5-m Baker-Nunn camera, with support from the Cross Educational Foundation, the Natural Sciences and Engineering Research Council of Canada and the University of Calgary. The alt-alt mounted infrared telescope is under construction in the Technical Services Workshops of the University and will be installed beneath a 36-foot dome. When completed, the infrared telescope will be used for photometry and Fourier transform spectroscopy of close binary stars, galactic H II regions and, with suitable filtering, the sun.

The Baker-Nunn camera, a gift from the Canadian Armed Forces, will reside in the 12-foot dome at the west end of the new building, and will be used for wide-field photography, particularly of comets. The building also includes a preparation area for balloon-borne telescopes and an aeronomy laboratory.

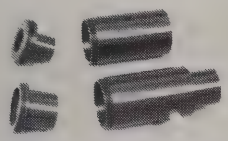
NEW LUMICON® PRODUCTS

LUMICON, 2111 Research Dr., #5
Livermore, CA 94550 (415) 447-9570

NEW! NON-ROTATING HELICAL FOCUSER

LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON has just designed a deluxe smooth helical focuser with non-rotating 2" i.d. eyepiece holder. It has a vertical travel of 1¼" and a very low profile only 1½" high. It is CNC machined, black anodized, and a perfect match to LUMICON EASY-GUIDERS.
Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 20" OD, SUPER-FINDER base plate.

LUMICON Deluxe Helical Focuser ... **$79.50**
3 handles (see photo) **$12.95**
Helical focuser with 3 handles **$92.40**
2"/1¼" adapter w/48mm filter threads **$20.00**
2" LUMICON EASY-GUIDER **$169.50**

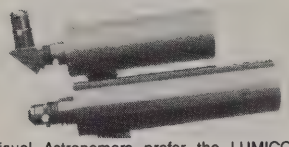


EYEPIECE PROJECTION

These adapters allow high magnification photography of the Moon and Planets using eyepiece projection. They may be used without any eyepiece for prime-focus photography. All adapters use standard camera T-rings.

Tele-Extender for Meade or Celestron SCT. **$32**
1¼" Basic Camera adapter, 2 part system **$32**
0.96" Basic Camera adapter, 2 part system **$32**
1¼" prime Focus adapter, fits 1¼" focuser **$22**
0.96" prime Focus adapter, fits 0.96" focuser **$22**
Camera T-ring, specify 35mm camera type **$12**

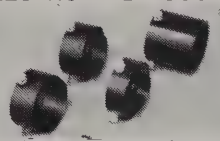
LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F=500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle **$89.50**
1¼" straight-thru 80mm SUPER-FINDER ... **$169**
1¼" right-angle version, w/star diagonal **$195**
2" right-angle version, non-rotating focuser .. **$199**
1¼" Deluxe right-angle Super-Finder* **$279**
2" Deluxe right-angle Super-Finder* **$309**
25mm Cross-hair 1¼" eyepiece (12X) **$29**
*1¼" Star Diag. **$32**, 2" Star Diag., silver, **$145**
1¼" Amici Prism diag. for correct left-right views **$59.50**

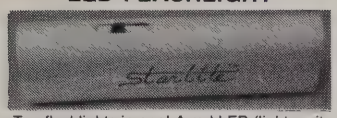
2" ADAPTERS MEADE, CELESTRON TELESCOPES



These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

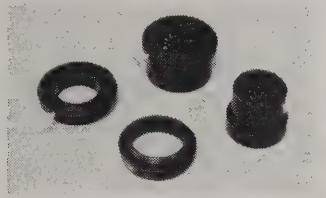
2" adapter for C-8, Meade 2080, etc. ... **$26.00**
2" adapter for Criterion 4000, 8000 ... **$26.00**
2" adapter for C-80, C-90, C-100 ..... **$39.50**
2" adapter for C-70, C-80F, C-90F, C-100F **$39.50**
2" Accessory adapter for Comet Catcher*, C-6*, Meade 310, 320 refractor **$30.00**
2" adapter for Takahashi E-130, 160 .. **$59.50**

ASTRONOMER'S LED FLASHLIGHT



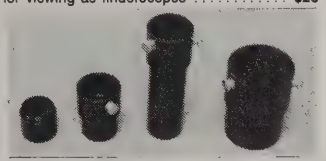
Two flashlights in one! A red LED (light emitting diode) is ideal to read star maps and preserves your eye's dark adaption. A brighter green LED help you to find things in the dark. No bulb to burn out, 3 AA batteries last many months. (Batteries not included.)

Starlight™ LED Flashlight **$14.95**
Red/White Standard Flashlight .. **$14.95**



VIEWING ADAPTERS

2"/1¼" Adapter, threaded 48mm filters .. **$20**
2"/T - Thread adapter, threaded 48mm .. **$25**
T - Thread/1¼" adapter. Converts telephoto lenses for viewing as finderscopes **$25**



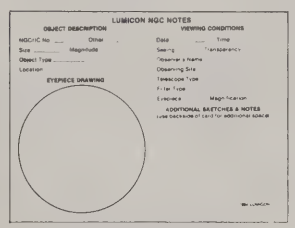
EXTENSION TUBES

1.0" long Thread-in extension tube **$12.00**
1-2½" long, threaded for 1¼" filters **$16.00**
4½" long extension tube, 1¼" i.d. **$25.00**
2" i.d. Extension tube, 3" long, threaded for 48mm filters, adds 1.6-3.0" **$26.00**

48mm COLORED GLASS FILTERS

These 48mm Filters thread into LUMICON EASY-GUIDERS and most 2" eyepieces. Use adapter for 1¼" eyepieces. AR Coated.

Filter:	Bandpass	Trans	Price
Ultraviolet	320-420nm	85%	$35
Minus Violet	420nm-IR	96%	$29
Blue Tricolor	340-470nm	80%	$35
Hi Perf. Blue	300-540nm	95%	$35
Yellow	480nm-IR	98%	$18
Green	490-590nm	60%	$18
Orange	560nm-IR	98%	$18
Red	600nm-IR	98%	$18
H-Alpha Pass	640nm-IR	95%	$35
Cyan	340-580nm	95%	$59



NGC NOTES

These handy **NGC NOTES** are stiff 4"X5½" cards. the **NGC NOTES** fit in your hand and are ideal for making notes and sketches while observing at the eyepiece. Making sketches **greatly improves** your observing skills and also gives you a permanent record. Get 200 **NGC NOTES** for Messier objects; NGC object observers should get 400-800 **NGC NOTES.**

NGC NOTES, Pack of 200 ..... **$9.95**
Pack of 400 **$17.95** Pack of 800 **$32.95**

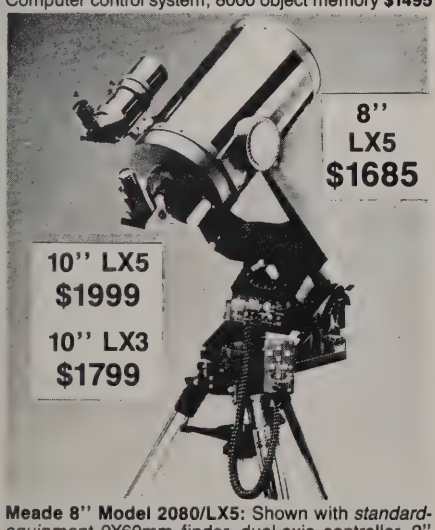
Meade® TELESCOPES AT LUMICON

New Meade MTS telescopes in stock!
6" f/4 $595, 8" f/4 $895, 8" SCT $895, 10" SCT $1495
Call for details on available options for MTS telescopes

NEW! 2080/LX5 ..... $1685
MEADE 2120/LX5 ..... $1999

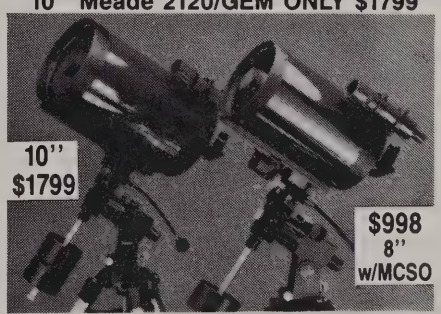
The most advanced Schmidt-Cassegrain telescope available! *Standard equipment* includes dual-axis hand-held electronic command center, 2" mirror star diagonal, 9X60mm polar viewfinder, multi-coated/enhanced optics, 26mm Super Plossl, tripod and wedge.

#39 Electric declination for 2080 or 2120/LX5 **$109**
Dew shield-essential 8" (#712) **$65**; 10" (#710) **$98**
Accessory shelf for field tripod ($40 list) **$28**
LUMICON EASY-GUIDER/Rich-Field viewer: for 2080 (f/6 operation) **$225**; for 2120 (f/4-f/10 operation) **$395**
Computer control system, 8000 object memory **$1495**



Meade 8" Model 2080/LX5: Shown with *standard-equipment* 9X60mm finder, dual-axis controller, 2" Diagonal Mirror, Equatorial Wedge, Field Tripod.

10" Meade 2120/GEM ONLY $1799



Meade 2120/GEM (left) and 8" 2080/GEM Schmidt-Cassegrain optics on German Equatorial Mount.

2080/GEM, 8" f/10 w/MCSO, equatorial mount **$998**
2120/LX3 10" f/10 w/MCSO, wedge, tripod . **$1799**
2120/GEM, 10" f/10 w/MCSO, equatorial mount **$1799**
Dew shield & accessory tray, 8" **$72;** 10" **$144**
#784 Motor & quartz drive corrector ($310 list) **$219**
Computer Control system, 8000 object memory **$1495**
Solar Filter for 2080 ... **$149;** for 2120 ... **$185**

4" MEADE 2045 w/table tripod $595

4" f/10 Meade 2045/LX3 w/quartz drive **$795**
#36 dual-axis cont. (LX3) **$99,** #38A dec. motor **$99**
Wedge & field tripod for Meade 2045 ($380 list) **$298**
Dew shield ($80 list) .. **$55;** Solar Filter .. **$95**

FILTERS STOP POLLUTION

LUMICON UHC Filter™ for nebulae. Standard 1¼" **$79**
Prem 1¼" **$99;** Std 48mm **$159.50;** Prem 48mm **$199.50**
LUMICON Deep-Sky Filter™, 1¼" Premium ... **$79**
48mm Prem Deep-Sky **$119.50, $99.95** w/Easy-Guider
Adapter for viewing w/1¼" eyepiece **$20**

PHOTOGRAPHY ACCESSORIES

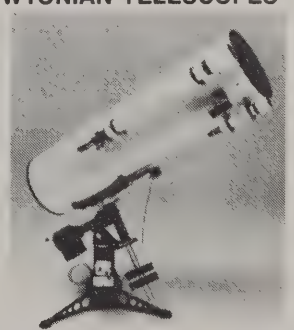
LUMICON Newtonian Easy-Guider, 1¼" or 2" **$169**
LUMICON Cassegrain EASY-GUIDER for Meade 2045, 2080/LX5 and 2080/GEM (state camera) **$225**
Illuminated reticle eyepiece & battery pack **$89.50**
Dual-axis Drive corrector **$219**

These Meade Telescopes are complete and ready for viewing.

They include telescope with all coated optics for high transmission, mount, tripod or pier with legs, motor drive (except models 6600, 8800, GEM series). Finderscope, at least one eyepiece, and complete instructions. Call or write LUMICON for full technical information. MCSO means multi-coated silvered optics.

MEADE NEWTONIAN TELESCOPES

16" f/4.5 MEADE DS-16A only $1975



Note: Astrophotographers should order optional sealmaster ball bearings for the DS-16A (add $229).

Model 6600, 6" f/5 w/1¼" focuser, 6X30 finder **$685**
Model 628c, 6" f/8 w/motor, 2" focuser, 8X50 finder **$798**
Model 645c, 6" f/5 w/motor, 2" focuser, 8X50 finder **$829**
Model 8800, 8" f/4.5 w/1¼" focuser, 6X30 finder **$895**
Model 826c, 8" f/6 w/motor, 2" focuser, 8X50 finder **$975**
Model DS-10A, 10" f/4.5 w/motor, 2" focuser .. **$995**
Model DS-16A, 16" f/4.5 w/motor, 2" focuser . **$1975**
Sealmaster ball bearings for DS-16A, recommended! **add $229**
Finderscope for DS-10A, DS-16A, 8X50mm incl. mount **$109**

All foreign orders add 6% ($8 minimum). California residents add 6% tax. Prices subject to change w/o notice. Set Meade and LUMICON Catalogues $4. **LUMICON, 2111 Research Dr., #5, Livermore, CA 94550.** Call **(415) 447-9570** for information & orders. Store Hours: M-F 9am-5pm; Sat 11am-3pm. All telescopes shipped F.O.B. Livermore.

Observer's Page

Conducted by Dennis di Cicco

SKYSHOOTING WITH THE FASTEST COLOR FILM

KONICA has just introduced the world's fastest color film — Konica SR-V3200. While its speed alone (ISO 3,200) will be alluring to astrophotographers, its excellent color balance and spectral sensitivity are also desirable features.

During the 1970's the increasing speed of color films, in both transparency and negative emulsions, reached a temporary plateau when it matched that of the venerable black-and-white standard, Kodak Tri-X. Faster film generally meant grainier pictures, and that kept the speed from climbing higher.

Technological breakthroughs in the 1980's, however, have rocketed the speed of color film almost off the charts. Indeed, cameras and light meters made only a few years ago often lack a speed setting of ISO 1,600 on their dials, let alone 3,200. (ISO values have replaced the older ASA exposure indexes familiar to many photographers, though the numbers remain the same in both systems.)

Konica's new film, like its close kin Konica SR 1600 (reviewed by Bill Iburg on page 110 of the January issue), exhibits remarkably fine grain considering its speed. Slightly overexposing the film, thus producing a dense negative, further reduces the film's apparent grain. While overexposure is usually not associated with deep-sky photography, initial tests of Konica's new film reveal that relatively dense negatives of faint sky objects can be obtained with exposure times that are still quite reasonable.

Experienced astrophotographers might be quick to point out that fast films often show greater reciprocity failure* than slower emulsions. While this is true, the new emulsions reach the sky-fog limit with such short exposures that reciprocity failure does not play a major role. (I should add, however, that film speed alone is not the sole gauge of an emulsion's ability to detect weak signals. A slower film, though requiring a longer exposure to reach the sky-fog limit, may bring out a faint nebulosity against the background sky better, regardless of reciprocity failure.)

With short exposures the new films are less subject to annoying shifts in color balance that usually become more pronounced as exposure times lengthen. The new Konica film records the sky at a dark site as a neutral color.

So what will Konica SR-V3200 do? On the following three pages is a selection of pictures by several experienced astrophotographers who worked with different techniques. The images give a good feel for how the film performs. Because it is a negative emulsion, Konica SR-V3200 is primarily intended for making color prints. In the September issue, page 326, Tim Hunter explained how to make color slides by simply copying the negatives onto Kodak's type 5072 emulsion.

You don't have to use hypered film, a cold camera, or even a telescope to enjoy the benefits of Konica's film.

In addition to 35-mm format, I obtained several rolls of Konica SR-V3200 in the 120 size from a source in Japan. At my request, well-known Canadian astrophotographer Jack Newton tested this film (arm twisting was *not* an issue). Using his 20-inch f/5 reflector and a specially designed cold camera, Newton covered more than a 1° field with the larger film size. His 3-minute shot of M31 opposite reveals numerous dust lanes within the galaxy's spiral arms. "It's almost 'hand-held' deep-sky photography," comments Newton. The film also has good red sensitivity, important for recording hydrogen-emission nebulae.

Newton feels that Konica SR-V3200 is up to five times faster in a cold camera than when exposed at normal temperatures. Astrophotographer Jack Marling in California finds the film "perhaps two or more times" faster when hypersensitized in forming gas (8 percent hydrogen and 92 percent nitrogen) as compared to exposing it untreated. His initial experiments used film that was hypersensitized for 18 hours at 50° C in a Lumicon Model 300 tank, with the gas pressure about 1 pound per square inch above atmospheric pressure.

Why would people *want* to hyper Konica SR-V3200 or use it in a cold camera when the film already reaches sky fog in only a few minutes exposure? Both Marling and Newton have experimented with color astrophotography through Lumicon Deep-Sky Filters. Even in moderately dark skies that have little light pollution, these filters improve the apparent contrast between emission nebulae and the sky. The results are better photographs, but exposures through the filters can run 45 minutes or more, even with fast films. Hypering or cooling is one way to shorten the exposure.

How long will the new film last? That's a question with two meanings. I have to wonder about the market for a photographic emulsion that is so fast it's difficult to use outside on a sunny day. Even at f/22 a daylight exposure of $^1/_{2000}$ second or shorter is required — beyond the limit of many cameras. And all the astrophotographers in the world probably don't buy as much film in a year as film companies want to sell in a day.

According to Paul Rinaldi of Konica U.S.A., Inc., after combining the sales of enough small markets like astrophotographers (wow! — a film company that recognizes astrophotographers as a consumer group) and sports photographers or photojournalists who work in low-light situations with telephoto lenses, there are enough sales to make the film a viable product. Furthermore, according to Rinaldi there is a certain "prestige" about having the fastest color film in the world.

As for the other meaning of how long the film will last, anyone who considers hoarding it now, lest it become scarce in the future, should consider the following. Soon after Kodak introduced its ISO 1,000 color-negative emulsion a few years ago, it warned against using the film after the date stamped on the package, even if the film were stored in a freezer. The reason was degraded image quality due to background radiation from cosmic rays and the like.

You don't have to use hypered film, a cold camera, or even a telescope to enjoy the benefits of Konica's new product. Consider the exposure of Cygnus on page 561 by Jeff Peronto and Ted Thousard of DeForest, Wisconsin. In the mid-1960's one of my most cherished photographs was a shot of the same region showing a hint of the North America nebula. Mine was made with a 58-mm f/1.4 lens and many minutes of guided exposure on Anscochrome film (ASA 100). With a similar-speed lens and Konica SR-V3200, the two Wisconsinites obtained a better image in 30 seconds with the camera fixed to a tripod! Astrophotographers are in for some interesting times.

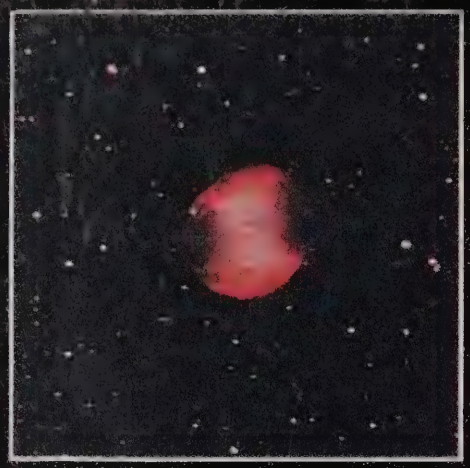
DENNIS DI CICCO

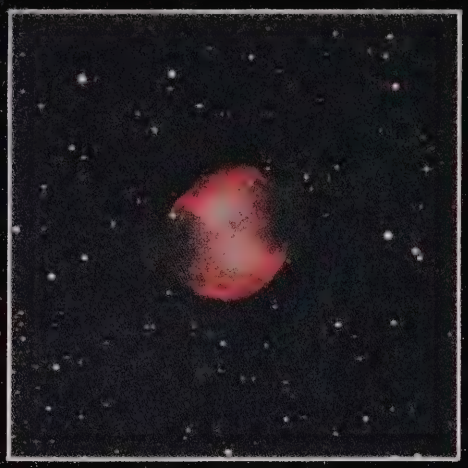
*A well-known reciprocal relationship tells us that with half as much light we need twice the exposure time to produce a negative of constant density. But at long exposure times this "law" begins to fail and we need three, four, or more times the "predicted" exposure to achieve the same results.

Above: Canadian astrophotographer Jack Newton compares the new Konica SR-V3200 emulsion exposed 9 minutes at air temperature (*left*), and 3 minutes in a plug-type cold camera charged with dry ice (*right*). Both views of the Andromeda galaxy, M31, were made with his 20-inch f/5 reflector and a sample of the film in 120 format. Newton believes that longer exposures would not have produced better pictures since each negative was at its sky-fog limit.

Right: The new film's excellent blue sensitivity is apparent in Newton's 6-minute exposure of the Pleiades, taken with the same cold camera and telescope as above.

Konica SR-V3200's versatility is clear from these Newton photographs with a cold camera and 35-mm film. At far left is an 18-minute exposure through a Lumicon Deep-Sky Filter of the red emission nebula NGC 7635 in Cassiopeia, also known as the Bubble nebula. Beside it is a 5-minute cooled exposure, without filter, of the well-known Whirlpool galaxy, M51.



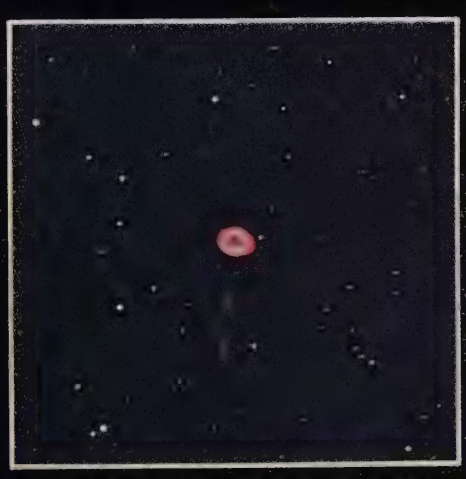


Above: Jack Marling compared gas-hypered Konica SR-V3200 with unhypered samples of the same film (see the text for procedure). His exposures of the Dumbbell nebula, M27, were made with a Deep-Sky Filter and a 17½-inch f/4.5 reflector equipped with a silver-coated secondary mirror that improved light throughput. From *left* his exposures are 6 minutes on normal film, and 3 and 6 minutes on hypered emulsion.

Left: Who needs long exposures? Dennis di Cicco used a sample of Konica's ISO 3,200 film in 120 format for a series of guided photographs of Cygnus with an 80-mm lens working at f/3.5. Compare the 5-minute exposure at *left* with the 30-minute view at *lower right*. While the longer exposure produced a denser negative, it contains essentially the same "information" as the shorter one.

Below left: Jack Newton recorded the "Gulf of Mexico" region of the North America nebula with a 20-minute cooled exposure by coupling a Deep-Sky Filter to his 20-inch reflector.

Compare these shots of the Veil nebula's eastern half, NGC 6992 and 6995. Jack Newton used Konica SR-V3200 and a Deep-Sky Filter. Both are 20-minute exposures with his 20-inch f/5 reflector, but the one at *left* was made with a cold camera charged with dry ice.



In Wisconsin, Jeff Peronto and Ted Thousard tested the new Konica film on several sky subjects. Using 8-inch f/10 Schmidt-Cassegrain telescopes, they photographed the globular cluster M13 (*left*) and Ring nebula M57 (*center*) with 15- and 16-minute exposures, respectively. Their shot of Cygnus (*right*) shows the North America nebula and emission nebulosity around Gamma Cygni in a mere 30-second exposure. The camera and 50-mm f/1.4 lens were fixed to a tripod.

CELESTIAL GUIDEBOOKS

The information you need about the sights that await you overhead.

Burnham's Celestial Handbook, Vol. 1
— Burnham *3567X* **$11.95**
A modern classic, indispensable for telescope owners. Detailed descriptions of all important deep-sky objects alphabetically by constellation. Vol. 1 covers Andromeda to Cetus and has an introduction for beginners. *652 pages, softbound.* (Levels 1-2)

Burnham's Celestial Handbook, Vol. 2
— Burnham *35688* **$11.95**
Covers Chameleon to Orion. *695 pages, softbound.* (Level 2)

Burnham's Celestial Handbook, Vol. 3
— Burnham *36730* **$12.95**
Covers Pavo to Vulpecula. *787 pages, softbound.* (Level 2)

All three Burnham handbooks:
C0003 **$36.85**

Webb Society Deep-Sky Observer's Handbooks
The Webb Society is a worldwide group of deep-sky enthusiasts. The handbooks they've compiled are an important amateur reference. All are softbound, levels 2-3.
— Vol. 1, 2nd edition *01222* **$13.95**
Describes 685 double and multiple stars. *192 pages.*
— Vol. 2 *00285* **$10.95**
182 nebulae are described, including 89 planetaries. *149 pages.*
— Vol. 3 *0034X* **$14.95**
268 open and globular clusters, with 229 finder charts. *206 pages.*
— Vol. 4 *00501* **$16.95**
275 galaxies, with drawings, details, and much text. *238 pages.*
— Vol. 5 *00668* **$16.95**
Clusters of galaxies. *241 pages.*
— Vol. 6 *01338* **$11.95**
Anonymous (non-NGC or IC) galaxies. *137 pages.*
— Vol. 7 *01346* **$15.95**
Highlights of the far-southern sky. *198 pages.*

New!

The Amateur Astronomer's Handbook, 3rd edition
— Muirden *14262* **$10.95,** *softbound*
16221 **$24.95,** *hardbound*
This is an excellent all-around one-volume guidebook to using an amateur telescope. It covers telescope functions and maintenance; a great many details of how to observe the Sun, Moon, planets, stars, and deep-sky objects; and introduces astrophotography and telescope making. Now available in both hardcover and paperback. 3rd edition. *472 pages.* (Level 1-2)

Astronomy with Binoculars
— Muirden *58323* **$7.95**
How to find hundreds of star clusters, nebulae, variable and double stars, galaxies, and more with simple (and cheap) optical aid. *156 pages, softbound.* (Levels 1-2)

Level 1 = beginner, Level 2 = intermediate amateur, Level 3 = advanced. Use the order form in the center of this issue. Your order is shipped postpaid in the U. S.!

SKY PUBLISHING CORPORATION
49 Bay State Road
P. O. Box 9102
Cambridge, Mass. 02238-9102

Comet Digest

DURING these crisp November evenings Comet Bradfield, 1987s, is best seen at the end of twilight. Moving northeastward among the stars of Ophiuchus, 1987s is expected to be as bright as 5th magnitude and faintly visible to the naked eye.

The comet will be crossing a rich section of the Milky Way, where deep-sky objects abound. As darkness falls on October 22nd, observers in North America will see 1987s pass just south of the globular cluster M10 in Ophiuchus. On the evening of November 14th it transits the loose open cluster NGC 6633. Moonlight will not interfere with either event.

As Comet Bradfield reaches perihelion early in November, we should expect to see a tail develop. With binoculars, or better yet a telescope, look for a straight, narrow gas tail and a broader, more diffuse dust tail pointing eastward from the glowing coma.

Comet Rudenko, 1987u, is another recent amateur discovery. It was found on the evening of August 20th by Michael Rudenko of Amherst, Massachusetts. As with his discovery of 1984t, he swept it up with a 6-inch refractor equipped with a Lumicon comet filter, which transmits specific wavelengths of light from a comet but blocks others from light pollution. Rudenko feels that he would not have discovered 1987u in his suburban location had it not been for the filter.

During November 1987u will be moving rapidly southward across Crater, Antlia, and Vela. Northern-Hemisphere observers will get their best look early in the month when it lies in the southeastern sky as morning twilight begins.

P/Borrelly, 1987p. Of the many comets mentioned in this column recently, only periodic Comet Borrelly still increases in brightness. During November it moves northwestward across Fornax and is best placed for viewing around local midnight.

As mentioned briefly last month, William Bradfield became the 20th century's greatest comet discoverer when he found his 13th comet on August 11th. With his 12th find in 1984, the Australian comet hunter entered a three-way tie with the late Leslie Peltier of the United States and Minoru Honda of Japan, both of whom had 12 confirmed visual discoveries. Later in 1984, professional astronomer Antonin Mrkos of Czechoslovakia joined the group when he found his 12th.

Peltier, a designer of children's furniture in Delphos, Ohio, diligently hunted comets with a 6-inch f/5 refractor from 1924 until the early 1960's and thereafter on a more casual basis until he died in 1980. His name is on only 10 comets listed in Brian Marsden's *Catalogue of Cometary Orbits.* It is understandable that Peltier's name is not attached to Comet 1943 II, since his sighting came more than two weeks after its discovery in Rumania. But why his name is missing from comet 1937 II is more of a mystery. According to Marsden, Peltier clearly caught sight of the comet within hours of its discovery by Wilk in Poland. At the time, however, the International Astronomical Union named the comet for Wilk, and it has remained so ever since.

Honda, the dean of Japanese amateur astronomers, has a comet-hunting career spanning more than 40 years. He discovered his first in 1940 along with fellow countryman Segeki Okabayasi. Following World War II, Honda began sweeping with a pair of 15 x 150 binoculars provided by the U. S. armed forces occupying his homeland. Between 1947 and 1955 he discovered five comets with the huge binoculars.

In Japan, Honda managed a children's school, while constructing an elaborate private observatory in his spare time. His interest in astronomical photography grew. By the mid-1960's his photographic work seemed to have largely supplanted his visual searches. He made numerous photographic nova discoveries in the late 1960's and 1970's. His last comet finds came in 1968 (there were three!).

P/BORRELLY, 1987p

1987	R.A. h m	Dec. ° ′	E °	Mag.
Oct 22	3 36.7	−38 05	125	8.4
Nov 1	3 26.2	−36 08	127	8.0
11	3 11.4	−32 04	131	7.7
21	2 55.0	−25 17	133	7.4
Dec 1	2 40.1	−15 40	134	7.2
11	2 29.6	−4 04	132	7.2

COMET BRADFIELD, 1987s

1987	R.A. h m	Dec. ° ′	E °	Mag.
Oct 22	16 55.1	−4 37	47	6.1
Nov 1	17 30.5	−0 24	48	5.7
11	18 10.6	+4 27	51	5.5
21	18 57.4	+9 50	56	5.5
Dec 1	19 53.2	+15 27	63	5.6
11	20 59.0	+20 38	71	5.9

COMET RUDENKO, 1987u

1987	R.A. h m	Dec. ° ′	E °	Mag.
Oct 22	11 42.4	+2 45	33	7.6
Nov 1	11 23.2	−10 05	44	8.0
11	11 02.0	−26 38	56	8.5
21	10 29.7	−45 44	68	9.1
Dec 1	9 22.5	−63 18	78	9.8
11	6 51.8	−73 01	83	10.6

These ephemerides give for each date at 0^h Universal time the comet's right ascension and declination in 2000.0 coordinates. Also given are the angular elongation *E* from the Sun and the visual magnitude predicted in the ICQ *1987 Comet Handbook.*

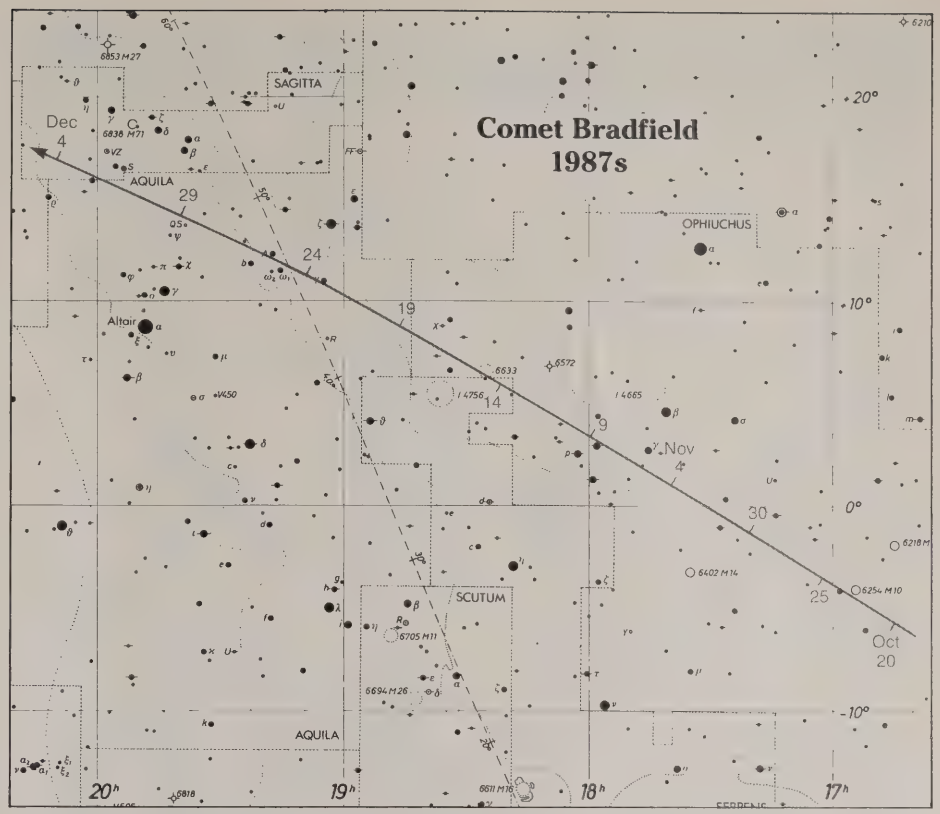
Mrkos located 11 comets between 1948 and 1959 with a pair of specially designed 25 x 110 binoculars. His most spectacular was Comet 1957V, described here last September. Like Honda, Mrkos is presently engaged in photographic work. His 12th comet was found on an asteroid-patrol photograph taken in 1984. Both Honda and Mrkos remain active.

Bradfield, a rocket engineer, began comet hunting much later in life than either Peltier or Honda. The appearance of brilliant Comet Bennett in 1970 deeply impressed Bradfield and left him with the desire to discover his own. In early 1971 he began sweeping with a homemade 6-inch refractor, described in the April, 1977, issue of this magazine, page 306. Just a little over a year later he found his first comet. His latest two finds were with a 10-inch reflector that he began using in the early 1980's.

As mentioned last month, all Bradfield's comets carry his name alone. Only three other observers — Jean-Louis Pons, William R. Brooks, and Edward Emerson Barnard — have more comets named solely for themselves. With another solo find, Bradfield will be tied with Barnard.

It is interesting to note that Marsden's catalogue associates the famous French comet hunter Charles Messier with only 13 discoveries. Matching that record is quite an achievement, and I suspect Bradfield must be very happy.

JOHN E. BORTLE
W. R. Brooks Observatory
R. R. #1, Box 198, Gold Rd.
Stormville, N. Y. 12582



Comet Bradfield, 1987s, may be faintly visible to the naked eye as it crosses the Milky Way in November. The comet's path is plotted on a section of the British Astronomical Association's *B.A.A. Star Charts* drawn by Wil Tirion. Coordinates are for equinox 1950.0, and dates are for 0h UT. Charts reproduced with permission of Enslow Publishers.

SUNSPOT NUMBERS

The following sunspot numbers have been derived by the AAVSO from observations by members of its Solar Division.

August 1, 65; **2,** 47; **3,** 38; **4,** 34; **5,** 29; **6,** 34; **7,** 43; **8,** 42; **9,** 42; **10,** 44; **11,** 52; **12,** 45; **13,** 48; **14,** 48; **15,** 50; **16,** 50; **17,** 47; **18,** 45; **19,** 49; **20,** 52; **21,** 49; **22,** 32; **23,** 37; **24,** 36; **25,** 36; **26,** 34; **27,** 28; **28,** 22; **29,** 10; **30,** 11; **31,** 18. Mean for August, 39.3. The AAVSO's final number for July is 34.3.

Below are provisional mean relative sunspot numbers as derived by A. Koeckelenbergh of the Sunspot Index Data Center in Brussels, Belgium.

August 1, 45; **2,** 47; **3,** 39; **4,** 33; **5,** 31; **6,** 32; **7,** 38; **8,** 45; **9,** 39; **10,** 47; **11,** 56; **12,** 48; **13,** 47; **14,** 49; **15,** 49; **16,** 55; **17,** 46; **18,** 43; **19,** 45; **20,** 51; **21,** 48; **22,** 34; **23,** 39; **24,** 35; **25,** 35; **26,** 34; **27,** 24; **28,** 23; **29,** 11; **30,** 10; **31,** 20. Mean for August, 38.6.

Dr. Koeckelenbergh predicts the following smoothed monthly sunspot numbers: November, 29; December, 30; January, 32; February, 33.

Protect Your Night Vision
Introducing
ASTROGOGGLES™

Rose Star Products

At Last! A product that allows dark adaptation under any conditions - daylight, dusk or artificial lighting. A red lens goggle - ASTROGOGGLES allow you to dark adapt and prepare for viewing under normal white light conditions since only red light reaches the eye. Dark adaptation is a complicated biochemical process that takes anywhere from 1 to 10 hours to complete depending on the amount of chemical "bleaching" sunlight has performed on retinal chemicals. In a dark environment the photon sensitive molecule Rhodopsin builds up and allows up to a multi million fold increase in sensitivity to light. Also Rhodopsin is maximally sensitive to blue-green light at 507 nanometers (nm). For this reason red light at +600 nm does little to affect Rhodopsin and maintains dark adaptation. These goggles have long been used by military and radiology professionals for this reason.

The lens and sidewalls of the ASTROGOGGLES are constructed of a deep red plastic material that allows passage of only red light. For long term wear they have comfortable soft sidewalls and special air vents so that no stray white light strikes the eye. Also, they can be worn over regular glasses. For your protection the lens is impact and ultraviolet safety rated.

No more waiting to dark adapt for viewing those faint celestial structures. Step up to your scope ready to observe. No more interrupted viewing from car headlights or from trips into the house for your favorite beverage. No more fussing at (or by) the family for "Lights out" when you come back in to use the bathroom.

Second to total darkness ASTROGOGGLES are the best answer to sensitizing your eyes to far flung photons. Listen - these things may look odd, but they work! So lengthen your effective viewing nights and order a pair.

Rose Star Products
2913 Teague Dr., Tyler, TX 75701

_____ Pair of Astrogoggles @ $19.95 _____
Plus $1.50 postage and handling U S _____
$3.00 foreign. Texas residents add
6% sales tax _____

Phone (214) 592-5218 Total _____

PHONE ORDERS ACCEPTED DAY OR NIGHT MON.-THURS. TILL 9:30 PM EDT. FRI. 9-2, SUN. 9:30-6

1987 ADORAMA

42 W. 18th St., New York, N.Y. 10011

SUSTAINING MEMBER

ORDERS & INFO (212) 741-0052

STORE HOURS: MON.-THURS. 9-6, FRI. 9-2, SUN. 9:30-6

FOR ORDERS ONLY: TOLL FREE OUT OF STATE 800-223-2500

HAWAII & ALASKA: 800-232-7662

Customer Relations: (212) 741-0466 (Mon.-Thur. 9-4:30 pm EDT, Fri. 9-2)

TELESCOPES ACCESSORIES

LUMICON

UHC FILTERS

1¼ 79.50
48mm f.most 2" EP 159.50

DEEP SKY FILTERS

.96" .... 59.50 1¼" 79.50
2" .... 99.50 48mm 119.50

H-BETA

1¼ ... 89.50 48mm ... 189.50

OXYGEN III

1¼ ... 99.50 48mm ... 199.50

TELRAD

Finder w/Mounting Base . 43.95

EASY GUIDERS

f/1¼ Newtonian Guider .. 169.50
f/2" Newtonian Guider .. 169.50
f/Cassegrain Guider 225.00
Giant Easy Guider f/C11, C14 or Meade 2120 ... 395.00

SOLAR FILTERS

8" Solar Filter 149.00
1¼" Solar Prominence Filter w/ Energy Rejection Pre-Filt . 550.
3" Off-Axis Metal Mask ... 68.00

DIGITRAK

DRIVE CORRECTORS

Digital quartz controlled. No knobs to adjust, solar-lunar-sidereal tracking rates, portable power, rechargeable battery in VE400/400D runs C8 up to 10 hours, a must for astrophotography.

VE300 Single axis, 12V DC input, remote control incl 132.95
VE300D Dual axis, 12V DC/120V AC input, remote ctl incl . 182.95
VE400 Single axis, internal battery, remote control incl .. 173.95
VE400D dual axis, internal battery, remote control incl . 212.954

FOCUS MOTORS

f/Celestron C-8, Powerstar 89.95
f/Meade 2080 LX3, 2120 LX3 .. .. 98.95
f/Meade 2080 LX5, 2120 LX5 ..... 98.95
f/Meade & Celestron Refractors 84.95
f/Tele Vue Renaissance 89.95
f/Bausch & Lomb 4000, 8000 ..... 98.95

PUBLICATIONS

Edmund Mag 6 StarAtlas . 16.95
Passport To The Stars 49.95
Celestron Sky Maps 15.95
Meade Star Charts 17.95
Celestron Product Guide/Ref. Manual 11.95

TELESCOPES PARTS

PARABOLIC MIRRORS

IDAI 4.5" w/Matching Elliptical Flats 59.95
IDAI 5" w/Matching Elliptical Flats 79.95
IDAI 6" w/Matching Elliptical Flats 119.95

MEADE PARABOLIC MIRRORS

6" f/8 ..... 139.95 8" f/6 ..... 219.95 10" f/4.5 ..... 409.95
6" f/5 ..... 149.95 10" f/6 ..... 409.95 12.5" f/6 .... 639.95
16" f4.5 ..... 899.95

MEADE ELLIPTICAL FLAT SECONDARY MIRRORS

1.3" ..... 35. 1.83" ..... 47. 2.6" ..... 55.
1.52" ..... 43. 2.14" ..... 50. 3.1" ..... 99.
4" ..... 120.

MEADE RACK & PINION FOCUSER

#67 1¼" ..... 49. #640 1¼" ..... 89. #680 1¼" ..... 109.

DUST COVERS

7½" ID ..... 14.95 9½" ID 19.95

BINOCULARS

SWIFT

MARK

Audubon 8.5x44 ..... 154.95
Ospry 7.5x42 (Armor) . 124.95
Condor 10x42 ..... 129.95

GIANT

Observer 11x80 BCF . 194.95
Satellite 20x80 BWCF . 194.95
Spotting Scopes
Telemstr 15-60x60 ... 189.95
Searcher 20x40x60(12.6°) . 219.95

CELESTRON

GIANT

*NEW MULTI-COATED
11x80 .... 299. 20x80 .... 309.
16x70 .... 249. 30x80 .... 299.
*Deluxe 14x80 ..... 499.95
20x80 Deluxe 429.95
*25x125 ..... Call
Car Window Mount 69.95

CLOSE OUT SPECIAL

7x35 Nova 79.95

STEINER

15x80 G Observer 513.95
15x80 C Obs w/Cmp .. 659.95
24x80 Telescope 399.95

MEADE

GIANT

11x80 Rubber Coated . 249.95
20x80 Rubber Coated . 259.95

NIKON

7x50 CF Star Vue 134.95
10x50 CF Sentinel 154.95
7x50 SPHP w/cs 449.95
10x70 HP w/case 354.95

SPOTTING SCOPES

W/CASE & 20X EYEPIECE

Spotting Scope 256.95
Spotting Scope ED ... 459.95
Photo Attachment 114.95
72mm Filter Ring 13.95
Hood 10.95
60X Eye Pc. Attch 49.95
15,30, 40xE.P. 46.95
Lens Scope Converter 49.95

ZEISS

15x60 CFT*GA w Cs . 1074.95
30x60 BGAT* ..... Call
Motor Foc f 30x60 ..... 139.95

FUJINON

7x50 MTR-SX 399.95
7x50 MTRC-SX 449.95
25x150 RA w Mt. Trpd 8499.95

SEE OPPOSITE PAGE FOR ORDERING INSTRUCTIONS

TELESCOPES

CELESTRON®

PRECISION OPTICS

SCHMIDT CASSEGRAIN TELESCOPES

POWERSTAR 8" —*INCLUDES: STARBRIGHT COATING, BUILT-IN DRIVE CORRECTOR, DC OPERATION, WEDGE and DEW SHIELD* 1499.95
NEW POWERSTAR 8 II ..... Call

ACCESSORIES FOR POWERSTAR

Dec. Motor 79.95
AC Adapter 17.95
Rechargeable DC Power Pack 69.95
Focus Motor 99.95
Car Battery Adapt 14.95

SUPER POLARIS C8

Super Polaris C8 ..... 849.95
Super Polaris C8 w/Starbright Coating ... 959.95

SUPER POLARIS ACCS

Single Axis Drive 139.95
Dual Axis Drive 199.95
Sky Sensor ..... Call
NEW COMPUTER CTL'D C8, C11, C14 . Call For Prices
C11 w/StarBright 3249.95
C14 w/StarBright 7299.95
C90 Astro Telescope 499.95

SUPER C8 PLUS

Super C8 Plus Blk w/Starbright Coating, Wdg, Trpd .. 1399.95
Adjustable Tripod 199.95
C8 Wedge 79.95
Sgl Axis Drive Corr 129.95
Dual Axis Drive Corr 219.95

REFLECTOR TELESCOPES

C102 5m Newtonian 349.95
Super Polaris 6-Inch Reflector (SP-C6) 649.95
Celestron Comet Catcher 256.95
Comet Catcher Equatorial Mount 299.95
Pulse Motor Drive fComet Catcher,C6 ..... 159.95

REFRACTOR TELESCOPES

Super Polaris C102 102mm Refractor 949.95
Super Polaris C80 Refractor 599.95

CAMERA DRIVE

For Northern Hemisphere 119.95
For Southern Hemisphere 129.95

SPOTTING SCOPES

C90 Spotting Scope 304.95
Super C90 Spotting Scope 404.95
NEW! Rubber Coated Super C90 ..... 439.95

CELESTRON C90 ACCS.

Barlow.96 2,2.5,3X .. Ea. 32.95
Ortho. 96 E.P 39.95
Kellner .96 E.P 34.95
Zoom Ocular .96 ..... 49.95
Delx Zoom .96 Ocular 59.95
E.P. Filter Set .96 ..... 49.95
Mult Ocular .96 Hold 69.95
Porro Prism .96 ..... 29.95
Series 5 Filter Set 49.95
Skylight Filter #1 ..... 31.95
Super C90 Conv. Kit 109.95
Wedge C90 ..... 73.95
Fork Mount & Drive 399.95
Deluxe Lat Adj C90 ..... 39.95

CELESTRON TELESCOPE ACCS.

Accessory Case 29.95
ALT Azimuth Adapter 59.95
Barlow 1¼" 2x,3x ..... Ea. 40.95
Barlow 2" 2x 79.95
Deluxe Barlow 1¼4" 2x .. 79.95
Chrmstr (Filt Wheel) 99.95
Counterwt Bar Assm 8" . 99.95
Counterweight Set 8" 59.95
DC Inverter 89.95
Dewstar/Shade 8" 24.95
10x70 Fndr C8 (Grabstar) . 219.95
16x70 Finder C8 ..... 249.95
8x50 RA Pol Find C8 ... 129.95
Illum Reticle EP 94.95
Illum Proj Reticle 1¼" ... 144.95
Image Corrector 1¼" 36.95
LPR Filter #1 ..... 109.95
LPR Filter #5 f/2" E.P. . 119.95
LPR Filter #3 7 ..... 69.95
LPR Filter #4 1¼ E.P. 69.95
Eyepiece Filter Set 1¼" .. 69.95
Eyepiece Filter Set 2" 74.95
Mult Ocular Hldr 1¼" 109.95
Off Axis Guiding Sys 159.95
Piggyback Mt 8/11/14 ..... 39.95
Polarizer Filter Assm 109.95
Polarizer Set 1¼" 49.95
Porro Prism 1¼" 38.95
Rich Field Lens f/1¼" EP . 29.95
Rich Field Adapt RFA ... 119.95
Rich Field 80 w/32 Erfle . 379.95
Series 6 Filter Set 54.95
Solar Filter 8" 279.95
Solar Filter Off Axis f/8" . 149.95
Slow Motion Control 39.95
Super Polaris 8" Mount . 499.95
Sky Filter #2 ..... 39.95
2" Widestar Diagonal 109.95
Twinstar (Dual Viewer) . 199.95
Tripod Accs Tray 64.95
Tele Extender 27.95
Tele Extender Ref, Newt . 44.95
Wide Star System 199.95
Wheels f/Adj Tripod 59.95

CELESTRON EYEPIECES

2" Plossl, Ortho, Erfle, Kellner 134.95
7.5,10,15,17,22,26,30,36,45mm 1¼" Plossl 64.95
16,24,28,32mm 1¼" Erfle 56.95
Zoom Ocular (8.4-21mm) 1¼" Ortho 79.95

ADORAMA

Portable Recharg DC Pk . 69.95
1¼ Ortho 6,9,12.5,18,25 . 39.95
1¼Plossl 10,13,17,24,36 . 54.95
1¼ Plossl 32mm 49.95
1¼ Star Diag 29.95
1¼ Barlow 2x,3x ..... @29.95
Rubber Eye Grd f..96 ..... 5.95
Rubber Eye Grd f.1¼EP .. 6.95
Rubber Eye Grd f2" EP 7.95

EYEPIECES & ACCS

Vari Cam. Adapt 1¼or.96 . 27.95
2" to 1¼ Adapt 24.95
1¼ to .96 EP Adapt Sys . 17.95
.96 to 1¼ EP Adapt Sys . 16.95
.96 Ortho 4,6,9,12.5 20,25mm 29.95
.96 Barlow 2x,3x ..... @ 29.95
2" E.P. Filter Set (6 pcs) . 59.95
2" Moon Filter (Polarizer) . 19.95

METEORITES

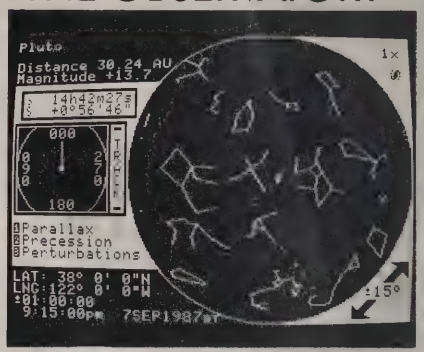
AVAILABLE TO ASTRONOMERS, SCHOOLS, INSTITUTIONS AND PRIVATE COLLECTORS. STONES & IRON SPECIMENS. **LIMITED SUPPLY.**

ROBERT A. HAAG — METEORITES

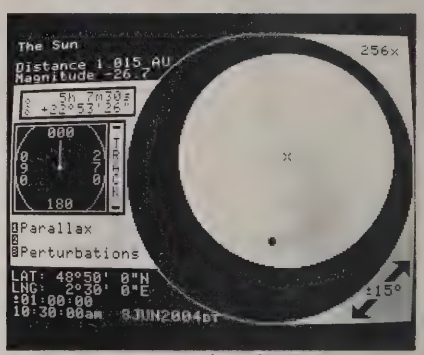
2990 E. Michigan St.
Box 27527, Tucson, AZ 85726

PLEASE SEND $1.00 FOR FULL COLOR CATALOG
Refundable with first order.

THE OBSERVATORY®



Autumn sky with constellations



Venus crossing the Sun

THE OBSERVATORY is an exciting sky simulator which is easy enough for the beginner, yet powerful enough for the more experienced astronomer. It displays hundreds of stars, with or without constellation lines, and all the planets as seen from any place on earth and for any time in 10,000 years. With 9 levels of magnification THE OBSERVATORY can bring into high resolution view the phases of the Moon, eclipses of the Sun, the moons of Jupiter, and even the rare solar transits by Mercury and Venus!

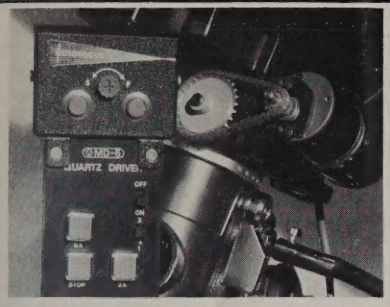
"THE OBSERVATORY *has many functions that will delight anyone with an interest in astronomy."*
—The Apple II Review, Winter, 1985

"THE OBSERVATORY *leaves the competition behind. All in all, it's one of the finest microcomputer programs on the market."*
—Sky & Telescope, May, 1986

APPLE II+ with 64K, IIe, IIc, IIgs $49.95

LIGHTSPEED SOFTWARE
Suite 185, Dept. S
2124 Kittredge Street
Berkeley, CA 94704
(415) 486-1165

Make Check or Money Order payable to Lightspeed Software. International orders add $8 shipping. APPLE is a registered trademark of Apple Computer, Inc.



DECLINATION MOTOR for CELESTRON'S POLARIS MOUNT. Also available for Super Polaris. Comes with hand-control attachment which attaches to Celestron's single-axis hand unit. . . . **$98.50**

NEW! DECLINATION MOTOR with hand-control for **TAKAHASHI EM-1. . . $98.50**

GEM OWNERS: Declination motor now available, similar to picture above. Turn your single axis into dual axis.
GEM dec . . . . . **.$98.50**
GEM Deluxe . . . . . **.$199.00**
(Deluxe includes Motofocus, GEM dec., and holder for Meade's R.A. switch box.)

NEW! MOTOFOCUS for LX5!

New push-on design. LX5 compatible has variable-speed control built into the back of the motor . . . . . **.$98.50**

NEW! MOTOFOCUS PUSH-ON MODEL. Fits all Meade 2080/2120's. Fast; easy installation. Weighs less than 6 oz. Variable-speed hand control. Battery and shipping included. **$98.50**

NEW! MOTOFOCUS ATTACHMENT for LX3. Battery-operated focusing control attaches to Meade's LX3 hand control. When ordering Motofocus request LX3 attachment at no extra cost.

MOTOFOCUS for C-5, C-8, Celestron refr., Meade Newt. & refr., Cave, Novak, Tele Vue Ren., Takahashi, Astro-Physics, Bausch & Lomb 4000, 8001. . . . **$89.95**

DELUXE MOTOFOCUS for C-14. Controls R.A., Dec., & focusing all in one hand unit. **$149.95**

NEW! "SNAP-ON" DECLINATION MOTOR for C-8, C-11, Meade 2080, 2120, 2045, B & L 4000, 8000, 8001 & Dynamax. Imagine a dec. motor that can be installed or removed in a few seconds! Available in different speeds: 2 r.p.m. for astrophotography; 8 r.p.m. for video cameras and visual slewing. Works with dual-axis drive corrector or battery-operated hand unit. Snaps on directly over declination shaft with friction drive.
MOTODEC **$69.95**
Hand unit with variable-speed control . **$20.00**

Dual-control hand unit FREE when ordering MOTOFOCUS and MOTODEC at the same time.

VISA, MC, check OK. We pay postage. Foreign: send bank check in U. S. $.

JIM'S MOBILE IND.
1960 Co. Rd. 23
Evergreen, CO 80439 (303) 277-0304

PHONE ORDERS ACCEPTED DAY OR NIGHT MON.-THURS. TILL 9:30 PM EDT. FRI. 9-2. SUN. 9:30-6

1987 **ADORAMA**
42 W. 18th St., New York, N.Y. 10011
SUSTAINING MEMBER

ORDERS & INFO (212) 741-0052
STORE HOURS: MON.-THURS. 9-6, FRI. 9-2, SUN. 9:30-6

FOR ORDERS ONLY: TOLL FREE OUT OF STATE **800-223-2500**
HAWAII & ALASKA: 800-232-7662
Customer Relations: (212) 741-0466 (Mon.-Thur. 9-4:30 pm EDT, Fri. 9-2)

COMPLETE W/MANUFACTURER'S ACCESSORIES

Meade
THE LEADER'S EDGE

Meade Authorized Dealer

SCHMIDT-CASSEGRAIN
2080 LX5 MC/OG
COMPLETE w/WEDGE & TRIPOD **CALL**
2120 LX5 w/MCGO
Complete w/Wedge & Tripod ... 2199.95

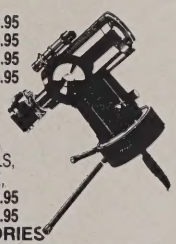
LX5 ACCESSORIES
#39 Dec Motor **96.95**
1200A Elec Focuser ..... **140.**

2080/LX3
w/MULTI COATED/SILVERED OPTICS GROUP (MCSO), COMPLETE WITH WEDGE & TRIPOD .. **New Low Price-Call**

LX TELESCOPE ACCS.
#36 Ctl Box ..... **87.** #38 Dec Motor . **86.**
#1401 Tube Balance Wghts f/2080 .. **86.95**
#1402 Tube Balance Wghts f/2120 .. **94.95**

2080 / 2120 GEM
2080 Gem w/HTC Coating ..... **Call**
2080 Gem w/MCSO Coating ..... **Call**
2120 Gem w/MCSO Coating **1849.95**

GEM ACCESSORIES
8x50 Polar Illum Viewfinder w/Brkt . **129.95**
#784 Quartz Drive **163.95**
DC Cord ..... **31.95** AC Cord **34.95**
#3000 Computer Control **1099.95**



2045
w/HIGH TRANSMISSION COATING, FORK MOUNT, CORD, SETTING CONTROL, SLOW MOTION CONTROLS, PRISM, 2 E.P., 5x24 FINDER, TABLE, TRIPOD & CASE **509.95**
2045/LX3 w/Multi Coated Optics **709.95**

2045 ACCESSORIES
4" Field Tripod & Wedge **239.95**
#43 Drive Corrector & AC/DC Conv **84.95**
#36 Control Box ..... **86.95** Piggy Back Bracket **18.95**
#38A Dec Motor ..... **85.95** #126 2X Barlow **47.95**
Ring Counterweight ..... **49.95** #582 Dew Shield **49.95**

MEADE ACCESSORIES
SERIES 4000 EYEPIECES

Super Plossl	Ultra Wide	Super Wide
6.4,9.7,12.4,15, 20,26 ..... **69.95**	4.7mm **129.95**	13.8mm **109.95**
	6.7mm **159.95**	18mm **119.95**
32, 40mm **89.95**	8.8mm(1¼,2") **189.95**	24.5mm **134.95**
56mm (2") **159.95**	14mm(1¼,2")**217.95**	32mm (2") **189.95**
Bar 2X,2.8X ..... **73.**		40mm (2") **248.95**

Series 2 Ortho 1¼ 4,6,12.5,18,25mm **49.95**
Series 2 Modified Achromatic 1¼ 6,9,12,25,40mm **39.95**
40mm 1¼ Extra-Wide Field MA **49.95**

BAUSCH & LOMB
ASTRONOMICAL TELESCOPES
NEW LOW LOW PRICES!!

61-6800 8" **639.95**
NEW 61-8001 8" Pro **799.95**
61-6600 6" ..... **Call**
61-6699 6000 Pro ..... **Call**
61-6400 4" Observatory **389.95**
61-6499 4000 Pro **399.95**
61-6440 4000 Spotting Scope **239.95**

ACCESSORIES

Pro Plossl 10, 17,26,35mm 1¼	**57.95**	63-1033 Off Axis Guider	**129.95**
		63-1020 RFT Assem	**87.95**
4,6mm 1¼ Ortho	**49.95**	63-1031 Nebula Filt	**63.95**
7,9,12.7,18,30mm		63-1088 Ser. 6 Filt Set ..	**49.95**
1¼ Symmetrical	**34.95**	63-1030 Drive Corr	**149.95**
63-1052 Porro Prism	**39.95**	Tripod & Wedge 4000 ..	**119.95**
63-1016 2x Barlow	**28.95**	Tripod & Wedge 6",8" ...	**279.00**

BAUSCH & LOMB DISCOVERER
78-1600 15-60x Spotting Scope **206.95**
22-3030 Camera Adapt ... **16.95** Car Window Mount **33.95**

SPACEMASTER
78-7817 Standard **149.95**
78-2300 45 ..... **154.95**
Camera Mount ..... **19.95** Shooter Stand Trpd **27.95**
NEW Spacemaster II (70mm Lens) w/Standard Eyepiece .. **159.95**

NEW! SPACEMASTER II (70mm)
78-1900 Spacemaster II **119.95**
15,20,25,60X Eye Pieces ..... **@ 36.95**
22X W.A. ..... **41.95** 15-45X Zoom **79.95**

Meade
THIS MONTH'S SPECIAL!
2080 LX3 MCSO **1249.95**
2120 LX3 MC/OG **1799.95**
2120 LX5 MC/OG **2199.95**
2045 ..... **489.95**
2045 LX3 ..... **649.95**
107D **279.95**
6600 Demo (Like New) **479.95**
8800 Demo (Like New) **699.95**
320 Demo (Like New) **469.95**

NEW MTS TELESCOPES
MTS-SC8 8" Schmidt Cassegrain **769.95**
MTS-SC10 10" Schmidt Cassegrain **1349.95**
MTS-SN6 6" Schmidt Newtonian **529.95**
MTS-SN8 8" Schmidt Newtonian **769.95**
All MTS Telescopes are also available with Multi-Coated Optics Group ..... *Call For Prices*

REFLECTING TELESCOPES
6600" f/5 ..... **599.95** 8800 8" f/4.5 ..... **799.95**

DEEP SPACE TELESCOPES
D.S.-10A ..... **849.95** D.S.-16A **1794.95**

REFRACTING TELESCOPES
294 60mm f/15 Equatorial **314.95**
310 80mm f/11 Altazimuth **394.95**
320 80mm f/11 Equatorial **579.95**
440/GEM 102mm f/10 Equatorial **1049.95**
277 2.4" f/5 Refractor **119.95**

TELESCOPE ACCS.

Accs. Case #50	**69.95**	#910 Nebular Filter 2" ..	**124.95**
2X Barlow #122	**44.95**	#911 Nebular Filter	**116.95**
Carry Cs f/Tpd&Wdg	**84.95**	Dew Shield (2080)	**59.95**
Variable 2X,3X	**59.95**	Dew Shield (2120)	**94.95**
Rotary EP Holder 1¼" ..	**113.95**	Piggy Bk Brkt 2080/2180 .	**39.95**
45° Erect Image E.P.	**44.95**	Tele Extender	**29.95**
Wide Field Adapt Sys ...	**119.95**	Tele Compressor Sys	**65.95**
2" Star Diag	**176.95**	8x50 Pol Illum Find	**129.95**
Off Axis Guider Assm ...	**149.95**	9x60 Polar Illuminated Finder w/Bracket	**169.95**
Illum Reticle E.P.	**83.95**		
Photo Visual Filt Set (6) .	**38.95**	#43 R.A. Drive	**89.95**
#1A Sky Filter	**44.95**	#1200 Electric Focuser .	**151.95**
#908 Nebular Filter 1¼ ..	**58.95**	LED Map Light	**27.95**

SPOTTING SCOPES

Pathfndr 15x60X Zoom .	**244.95**	97E 3.5" Complete	**349.95**
97D 3.5" Complete	**306.95**	107D 4" Complete	**349.95**

Photo Tripod #77 ..... **69.95**
Equatorial Mount & Tripod #100 ..... **264.95**

TELE VUE
PLOSSL

55mm 2"	**Call**
40,32mm 1¼"	**Call**
26,21,17,13, 10.5,7.4mm 1¼"	**73.95**

WIDEFIELD

40mm 2"	**Call**
32mm 2"	**Call**
24mm 1¼"	**Call**
19mm 1¼"	**Call**
15mm 1¼"	**Call**

NAGLER

20mm Type 2; 2"	**Call**
16mm Type 2; 2,1¼"	**Call**
13mm 2,1¼"	**Call**
12mm Type 2; 2,1¼"	**Call**
11mm 2,1¼"	**Call**
9mm 2,1¼"	**Call**
7mm	**Call**
4.8mm	**Call**

BARLOW
2X, 1.8X 1¼" ..... **Call**

ACCESSORIES
2" Star Diagonal **149.95**
Rich Field Kit (55 Plossl, 2" Star Diag., Adapter, Reducer) . **299.95**
9mm Guide E.P ..... **79.95** E.P. Projection Adapter ... **79.95**
1¼ E.P. Adapter f/Questar **69.95**

ORACLE
New ORACLE 3 3" f/7.4 Apochromatic Tele.
The New ORACLE 3 is a high resolution, high contrast wide angle versatile scope.
CALL FOR OUR LOW PRICE

the RENAISSANCE™
4" f/5.5 Wide Field Tele .... **Call**
RSM-2000 System Mt **399.95**
RWD-2204 Wood Trpd . **279.95**
RAL-2201 Alum Trpd ... **174.95**
RTR-2023 Tube Hldr Rings . **80.**

EDMUND SCIENTIFIC
Astroscan 2001 ..... **239.95**
Edmund Scientific's affordable wide-field, go-anywhere telescope gives super bright images.
RKE Eyepieces **29.95**
Orthoscope E.P. **41.95**
2.5 Rke Barlow **47.95**

Goodwin Barlow **21.95**
Roof Prism Image Erctr .. **54.95**
90 Prism Erector **29.95**
Vario Tube Cam. Adapt .. **41.95**
Tripod Bracket **27.95**
Tote Bag **24.95**

WE WILL ALSO BUY OR TRADE YOUR OLD TELESCOPE

WE SHIP PROMPTLY
No Surcharge for MasterCharge or Visa Purchases. Personal checks welcome, will ship without delay. Name must be imprinted on check, also include address, phone, and a copy of major credit card or drivers license for reference. Shipping Charges: $5.95 + over 3 lbs. 50¢/lb., + over $750.00 2% of value. Otherwise 3%. 14 day money back guarantee less shipping, with packing and blank warranty card, except film and paper. We ship UPS. Some items special order. All orders are subject to acceptance and verification. Products in this ad are supplied with Adorama's own exclusive warranty. Copies are available upon written request, may not include English instruction. Products are parallel imports which are not accompanied by manufacturer's warranty and not eligible for rebates offered by manufacturer unless mfg. or dist. warranty included. Second hand dealers license #802862. Pictures are for illustration purposes only and may not be exact.
Prices effective till NOV 3, '87

READERS' SERVICE FORM

Complete your library or satisfy a particular interest with reference issues of **Sky & Telescope!**

Here is your chance to get the back issues of **Sky & Telescope** that you have always wanted. Below we have listed highlights from a few of these issues for your perusal. All are packed with the information and photographs that make **Sky & Telescope** the most factual and exciting astronomical magazine around.

Just list below any issues you're interested in from 1981 on. Send $3.00 (domestic) or $4.00 (foreign) per magazine. Offer good while supply lasts; prices include postage. October, 1981, August, 1982, January through April, 1985, and January, 1986, are out of print.

1984

Mar. — The boom in small-telescope photometry
Infrared images of the Orion nebula
Modeling national new technology telescopes

Apr. — The early telescopes of Warner & Swasey
Alec Boksenberg: king of the castle
Vision and the amateur astronomer

May — EXOSAT: Europe's new X-ray satellite

Jun. — Solar Max: back from the edge
Light pollution: a status report
The search for extraterrestrial life

Jul. — Fires from heaven and hell

Quantity . . . . . Date of issue

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Subscribe to **Sky & Telescope!** (Prices increase January 1st!)

☐ New ☐ Renewal ☐ Gift subscription for:	1 year	2 years	3 years
Rates: **United States and possessions**	**$20.00**	**$37.00**	**$54.00**
Europe, Africa, West Asia (expedited delivery)	$35.00	$67.00	—
Canada, Mexico, elsewhere (by surface mail)	$23.50	$44.00	$64.50

Please note: The subscription prices listed above are complete. Do not add sales tax or postage charges. Please enclose payment. Foreign payments must be in U. S. funds drawn on a U. S. bank or by International Money Order.

Name . . . . . .

Address . . . . . .

City . . . . . State . . . . . Zip Code . . . . . .

Gift Subscription — Please send **Sky & Telescope** to: ☐ New ☐ Renewal

Name . . . . . .

Address . . . . . .

City . . . . . State . . . . . Zip Code . . . . . .

Please send gift card and sign . . . . . .

Free sample copy: ☐ *Sky & Telescope* magazine ☐ Sky Publications catalogue

Name . . . . . .

Address . . . . . .

City . . . . . State . . . . . Zip Code . . . . . .

Change of Address: *Please attach a current mailing label if possible.*

Old

Name . . . . . .

Address . . . . . .

City . . . . . State . . . . . Zip Code . . . . . .

New

Address . . . . . .

City . . . . . State . . . . . Zip Code . . . . . .

11-87 Use the mailing envelope in the center of this issue, or write to:

SKY PUBLISHING CORPORATION
49 Bay State Rd., P. O. Box 9102, Cambridge, Mass. 02238-9102

INDEX TO ADVERTISERS

A.A. Star Systems 517
AB Machining 516
Ad-Libs Astronomics 505
Adorama 564, 565
Advanced Technology Instruments 517
Archaeoastronomy 512
Ash Manufacturing Co., Inc. 556
Astro Audio Co. 518
Astro Cards 507
Astro Link 531
Astronomical Workshop 515
Astronomics 491
Astronomy Book Club 497
AstroSoft Co. 500
Astro-Tech 515, 531
Astro Trader, The 520
Astro World 547
Atlantic Monthly Press, The 490
Augen Optics 540
AutoScope 542
Bushnell 567
Byers, Edward R., Co. 504
California Telescope Co. 519
Camera Discount Center 520
Celestial Innovations 535
Celestron International 568
Century Telescope Center 556
Chicago Optical 520
Clausing, P. A. 550
Cosmic Connections, Inc. 516
Cosmo-Logique 531
Coulter Optical Co. 538
Crown Publishers, Inc. 492
Cygnus-Quasar Books 491
Deen Publications 534
East African Travel Consultants Inc. 540
Economy Telescope Co. 504
Edelman's 540
Fairborn Press 491
Focus Camera 541
Freeman, W. H., and Co. 495
GMM Rubber Co. 536
Galaxy Optics 535
Gemini 547
Glanze, Allen R. 515
Goto Optical Mfg. Co. 530
Haag, Robert A. — Meteorites 564
Hirsch, Edwin 544
Jim's Mobile Ind. 537, 565
Kowaliski Diversified 556
Kufeld, Steve 504
Learning Technologies Inc. 554
Light Software 498
Lightspeed Software 564
Luft, Herbert A. 548
Lumicon 501, 524, 525, 557
MMI Corp. 498
Mathis, Thomas, Co. 548
Meade Instruments 522, 523
Meichsner, F. C., Co. 516
National Camera Exchange 502, 503
Neptune Pacific 535
New England Astro-Optics, Inc. 540
Northern Sky Telescopes 549
Novak, Kenneth F., & Co. 514
Observa-Dome Laboratories, Inc. 550
1000+ 529
Optec, Inc. 542
Optica b/c Co. 500
Optomechanics Research, Inc. 498
Orbic Systems, Inc. 512
Orion Telescope Center 532, 533
P.A.P. Coating Services 545
Parks Optical 553, 554
Paslow Optical Co. 498
Pauli's Optical 518, 546
Philatelic Collectors, Inc. 542
Photon Instruments, Ltd. 545
Quasar Optics 504
Questar Corp. 450
Rose Star Products 563
Science & Art Products 534
Scope City 554
Scope City Canada 556
Sky-Gazers Exchange 534
Sky Instruments 550
Sky Optical 545
Sky Publishing Corp. 504, 521
Sky Scientific 518
Special Optics 528
Spectra 515
Star-Liner Co. 550
Starry Messenger, The 542
Sunwest Space Systems, Inc. 547
Tectron Telescopes 496
Telescopics 518
Tele Vue Optics, Inc. 550, 551
Tesseract 516
Thousand Oaks Optical 520
Tuthill, Roger W., Inc. 500, 539
University Optics, Inc. 555
VERNONscope & Co. 496
Vogel Enterprises 507, 531
Willmann-Bell, Inc. 499
World of Oz, Ltd. 494
Zephyr Services 526

INTRODUCING THE

BAUSCH & LOMB 8001

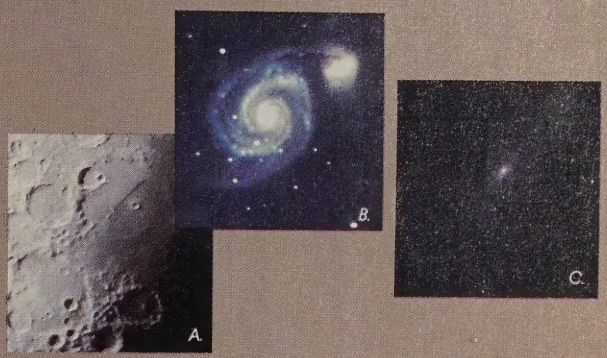
PROFESSIONAL MODEL OBSERVATORY TELESCOPE

When it comes to seeing far more — for far less — nothing compares with our amazing new 8001. The Bausch & Lomb 8-inch Schmidt-Cassegrain that offers sophisticated features like:

- Exclusive *5-inch diameter* declination setting circles that read from the side and the top for maximum accuracy and viewing comfort.
- Special optical coatings consisting of an enhanced aluminum primary mirror, silvered secondary mirror and magnesium fluoride coated corrector plate.
- Oversized primary mirror for full field illumination.
- Research-grade dual-motor clock drive with continuous feed gear train for uniform power transmission. Provides precise tracking both visually and photographically.
- A comprehensive system of optional accessories that allows you to add one at a time as your interests grow.

Best of all, the American-built 8001 comes from a company with over 133 years of experience in optical excellence and is backed by a limited lifetime warranty.

If you're considering buying a high-quality 8-inch telescope, look into the revolutionary new 8001. And see why it's the telescope system that's light-years ahead of the competition.



A. Lunar Craters photographed through the Bausch & Lomb 8" Schmidt/Cassegrain using eyepiece projection at an E.F.L. of over 32,000 mm!

B. Galaxy M-51 taken by Dr. Stephen Kent of Harvard University with the Bausch & Lomb 8" Schmidt/Cassegrain and a C.C.D. Exposure time — 10 minutes!

C. Galaxy M-31 taken by Jeff Peronto using a 300mm lens mounted piggyback on the Bausch & Lomb 8" Schmidt/Cassegrain. This photo is a 16 minute unguided exposure illustrating the superior accuracy of the Bausch & Lomb drive system.

When it comes to resolving Saturn's Cassini's Division, the New 8001 runs rings around the competition.

Contact your nearest Bausch & Lomb dealer, or contact us direct at: Bausch & Lomb Astronomical Telescopes 135 Prestige Park Circle • East Hartford, CT 06108 • (203) 282-0768

CELESTRON'S C11 & C14

Actual C14 photo, M22

Unrivaled light gathering ability in a quality, portabl telescope. The ideal instrument for serious astronomic pursuits. Astonishing close-ups of the moon, remarkable views of the planets, voyages across countless light years to distant star cluster galaxies and nebulae.

Experience the world's largest aperture catadioptri commercially produced telescopes. Computer designed, laser collimated, Starbright® coated Schmidt Cassegrain instruments built for a lifetim of visual and photographic applications.

Computer controlled models (Compustar 11 and 14) also available each with over 8000 objects in memory.

Celestron's C11 and C14, the professional quality instrument chosen by amateurs, schools and universities worldwide.

C11 in foreground, C14 in background

SPECIFICATIONS

	C14	C11
Clear Aperture	14″	11″
Focal Length	3910mm	2800mm
Photographic Speed	f/11	f/10
Magnification Range	50X-840X	40X-660X
Weight	116#	57#
Drive	Worm	Worm
Tube	Aluminum	Aluminum
Mount	Swing through fork	
Finder	8X50 Polaris	
# of Eyepieces	4	1
Focuser size	2″	2″
Setting Circles	Yes	Yes
Slow Motion	Yes	Yes
Limiting Magnitude Resolution	15	14.5

CELESTRON®

Celestron International
P.O. Box 3578, 2835 Columbia St.,
Torrance, CA 90503 (213) 328-9560
Call Free 1-800-421-1526 (Mon. - Fri. 8 - 4 pm;
Pacific Time in Continental USA only).